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CALCULATIONS OF MAXIMUM A-WEIGHTED SOUND LEVELS (DBA) RESULTING--ETC(U)
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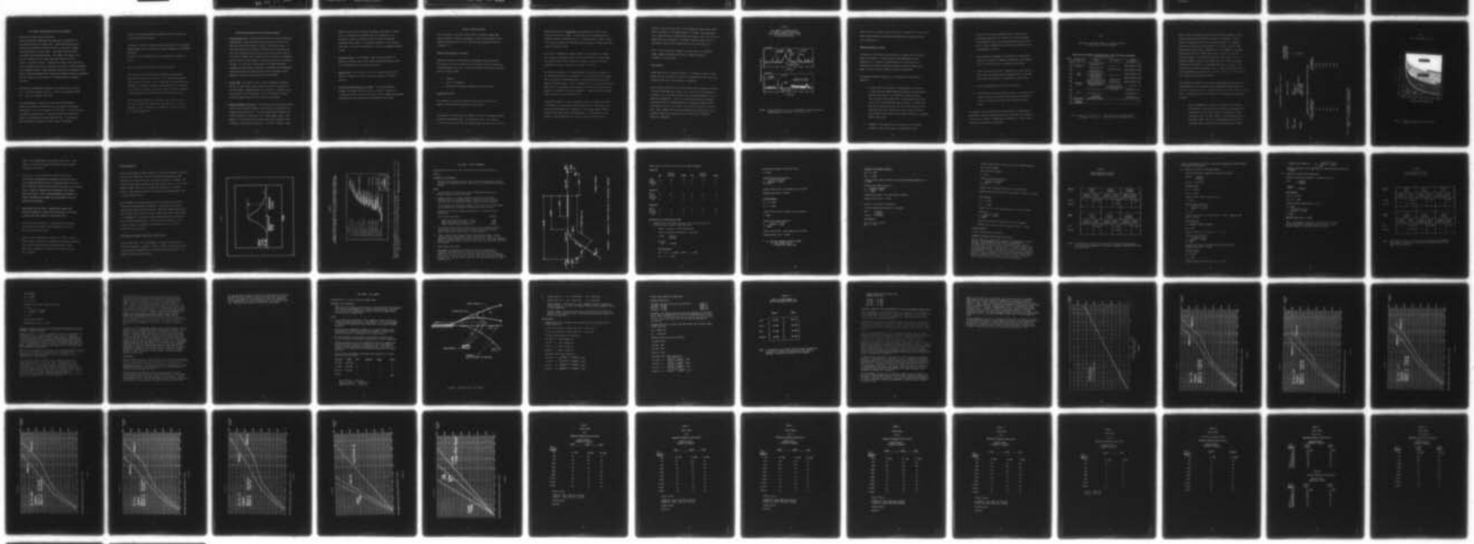

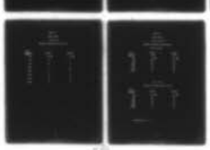

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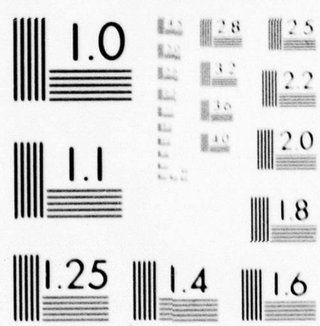


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

# LEVEL II

6

# CALCULATIONS OF MAXIMUM A-WEIGHTED SOUND LEVELS (dBA) RESULTING FROM CIVIL AIRCRAFT OPERATIONS.

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16. Abstract


This report provides detailed guidance on assessing noise impacts in peak levels for simple noise assessment involving introduction of jet service, changes in flight tracks, and other FAA actions which have noise impacts.


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## FOREWARD

This document presents a procedure for calculating and documenting in an environmental impact statement or negative declaration the maximum A-weighted sound level (in units of A-weighted decibels or dBA) for single aircraft operations at specified noise-sensitive locations in the vicinity of civil airports. The procedure will enable Air Traffic and Flight Standards personnel to calculate the maximum A-weighted sound level resulting from an aircraft takeoff or landing at any specified ground location in the vicinity of an airport. The procedure is relatively simple and straightforward. It has been developed to assist agency personnel in complying with the requirements of FAA Order 1050.1B, Policies and Procedures for Considering Environmental Impacts, paragraph 324b(2)(b). This guidance material includes aircraft flight profile information by aircraft type and mode of operation, and peak noise level as a function of slant range to the aircraft.

This procedure is not intended for developing noise contours around an entire airport or for calculating the maximum sound level at numerous points. If noise contours over a considerable area are needed, or if the airport in question has high aircraft activity, especially numerous turbojet operations, or flight tracks, it will be more prudent to use the FAA computer model - The Integrated Noise Model.

This document also includes an appendix that discusses the impact of noise on people and case studies for Air Traffic and Flight Standards personnel.

The case studies, along with the appendix, represent examples of the documentation that could be included as the noise section of an environmental impact statement or negative declaration. Actions which require an environmental impact statement, negative declaration, or environmental assessment are listed in FAA Order 1050.1B, Appendix 3, paragraph 4 for Air Traffic, and Appendix 4, paragraph 4 for Flight Standards. Requirements for a noise analysis are found in paragraph 324 of the order.

for J Kuesler

Director, Office of Environmental Quality

## CALCULATION OF THE MAXIMUM A-WEIGHTED SOUND LEVEL AT A POINT

The basic problem to be solved is illustrated in Figure 1 for the simple case of an identified noise-sensitive area (i.e., residential housing) exposed to noise from takeoffs of a single type of aircraft. To determine the maximum A-weighted sound level (in units of dBA) at the noise-sensitive area, one must be able to locate the airport runway and flight path with respect to the noise-sensitive area, and be able to identify the type of aircraft, the type of operation, and the closest point of approach between the aircraft and the noise-sensitive area. Essentially, one will be calculating the slant range distance "S" of the right triangle with legs "h" and "D." The Profile Charts included in this guidance material provide aircraft flight profile information by aircraft type and operational mode. The Profile Chart provides the altitude value for h. The distance $D_2$ is determined by measuring the perpendicular or closest distance ($D_2$) between flight track on the ground and the noise-sensitive area. The value for S is determined by the following equation:

$$S = \sqrt{(h)^2 + (D_2)^2}$$

Once the slant distance S is calculated, one can determine the maximum sound level in dBA at the noise-sensitive area with the use of the Noise Tables. The Noise Tables provide maximum sound levels by aircraft type and mode of operation as a function of slant range distance. However, field noise measurements and monitoring can be used for the assessment, or to validate theoretical computations. The theoretical values

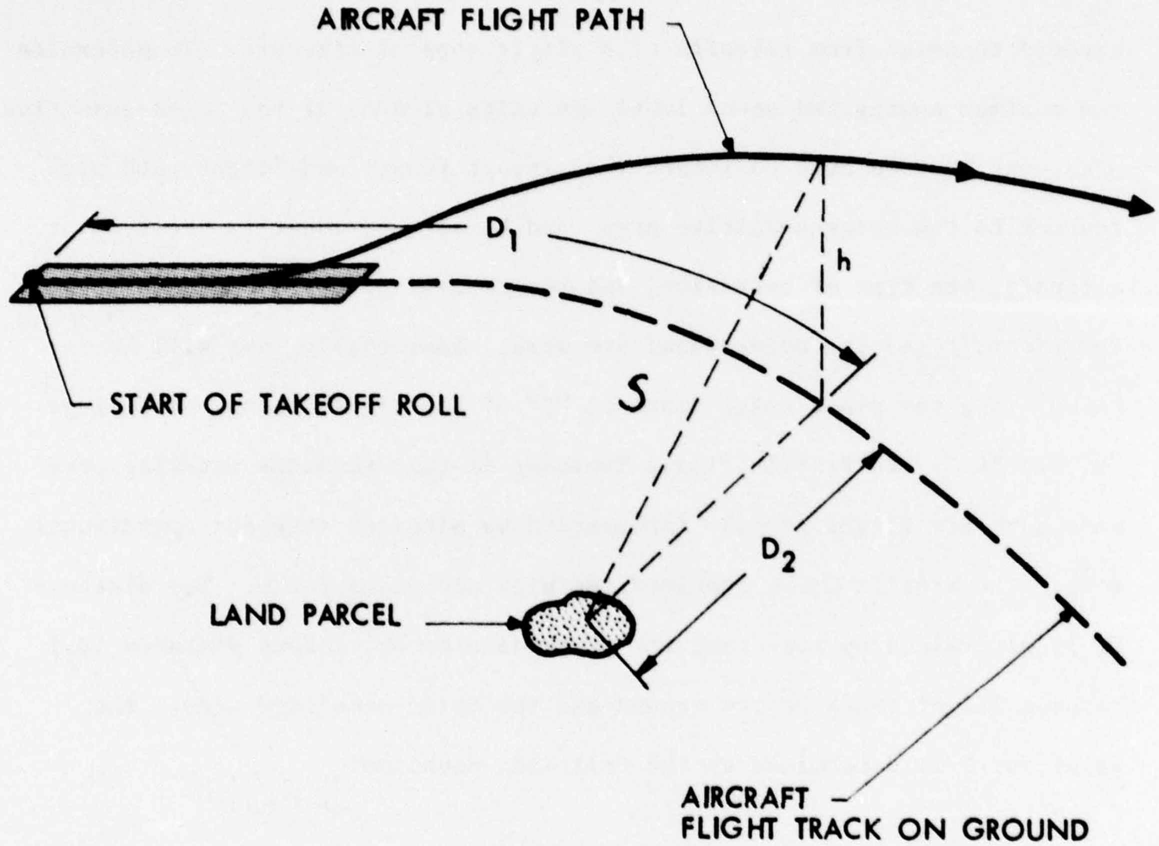



FIGURE 1. TAKEOFF

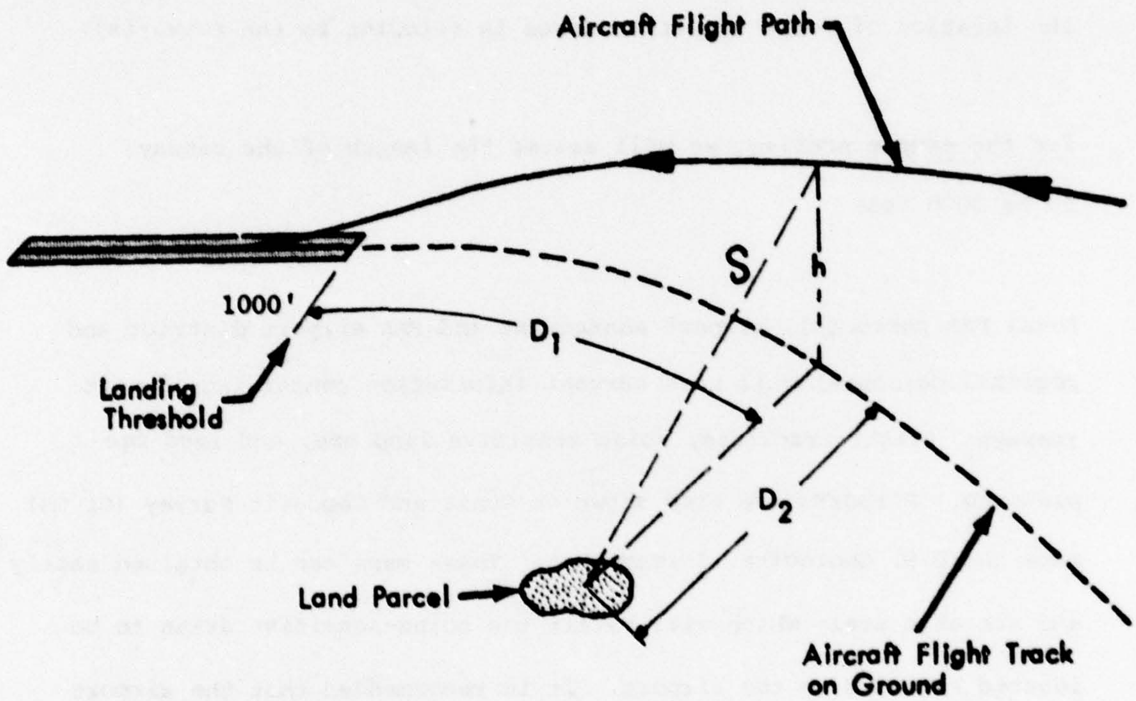



FIGURE 2. LANDING

are most useful for comparing changes in noise levels from FAA actions, but may not be accurate in predicting absolute noise levels.

Sample Problem - Calculate the maximum sound level in dBA at the land parcel shown in Figure 1 for the takeoff of a Boeing 727 with a trip length of 450 NM.

CALCULATION PROCEDURE

1. Determine the configuration and length of airport runway(s) and the location of noise sensitive areas in relation to the runway(s).

   For the sample problem, we will assume the length of the runway to be 8000 feet.

   Local FAA personnel, airport management and FAA airport district and regional personnel will have current information concerning airport runways, flight track use, noise sensitive land use, and land use planning. Airports are also shown on Coast and Geodetic Survey (C& GS) maps and U.S. Geological Survey maps. These maps can be obtained easily and are at a scale which will permit the noise-sensitive areas to be located relative to the airport. It is recommended that the airport information on these maps be verified to assure that it is current. Assessments should be consistent with prior FAA data, plans or assumptions regarding noise at a particular airport, or inconsistencies explained.

2. Determine the location of the major flight tracks over the ground, and the distances $D_1$, $D_2$ and h (Figure 1).
   The aircraft flight track must be located to determine actual distances from the noise sensitive area to the aircraft in flight. Once the track has been located, the distances $D_1$, $D_2$ and h can be determined.

For takeoffs, shown in Figure 1, $D_1$ is the distance along the flight track from the start of takeoff roll or brake release to a perpendicular drawn from the flight track to the noise sensitive area under consideration. $D_2$ is the distance along the perpendicular drawn from the flight track to the noise sensitive area. The distance h is the altitude of the aircraft where $D_1$ and $D_2$ meet.

For landing, as shown in Figure 2, $D_1$ is the distance along the flight track from the landing threshold to the perpendicular drawn from the flight track to the noise sensitive area. $D_2$ is the distance along this perpendicular from the flight track to the noise sensitive area. The distance h is the aircraft altitude. The landing threshold for most runways coincides with the physical end of the runway. However, at some airports the landing threshold is displaced along the runway. The presence of a displaced threshold can be verified by airport management, the FAA tower or the FAA airport district and regional office. A displaced threshold will not be shown on Coast and Geodetic Survey maps or U.S. Geological Survey maps. A displaced threshold will increase the distances for $D_1$ and h.

Unfortunately, aircraft do not follow precisely established flight tracks or climb profiles. The actual flight tracks fan out from the established flight track as aircraft get further from the airport. The turning point of one type of aircraft will not necessarily be representative of the mean flight track. The FAA tower, airport operations personnel or visual observations may help verify flight track or climb profile information.

For the sample problem, we assume the value of $D_1$ to be 21,000 feet. From the Profile Charts, the altitude (h) of a B-727 that is 21,000 feet from brake release ($D_1$) is approximately 1930 feet. Note that Profile A for the B-727 was selected (0-500 NM).

For the sample problem, we assume the value of $D_2$ to be 2000 feet.

3. Determine the slant range distance from the aircraft in flight to the noise sensitive area(s). A small electronic calculator simplifies this calculation greatly.

The slant range distance is determined by the following formula:

$$S = \sqrt{(h)^2 + (D_2)^2} = \sqrt{(1930)^2 + (2000)^2} = 2779 \text{ feet}$$

$S = 2779'$

4. Determine the maximum sound level (in dBA) for the distance S.

Locate the 727 in the Noise Tables. The slant range distance can be found on the left side of the table and the dBA values for takeoff and landing under the thrust levels (Table 6).

By interpolation, the maximum sound level for a slant range of 2779 feet is approximately 85 dBA. Note that the value under the 10,000 lb. thrust level was selected because the aircraft is above 1500 feet altitude.

Therefore, the maximum sound level in dBA of a departing 727 at the noise sensitive area is 85 dBA. Consult the section on Impact of Noise on People for a discussion of the interpretation of this sound level.

Obviously, the above simplified calculation procedure involves a number of approximations (i.e.: engine thrust settings, interpolations for slant distance, broad categories of aircraft gross weight, as represented by trip length). In addition, the procedure does not consider possible shielding of the sound from one or more of an aircraft's engines (when the aircraft is viewed from the side) or excess ground attenuation at lower angles of elevation ($\tan B = h/D_2$). Thus, in general, sound level values calculated by this procedure are conservative (possibly higher than actual).

This simplified procedure also assumes that the points on the ground, for which maximum sound levels are calculated, lie in the same horizontal plane as the airport. Differences in height can be included easily by adjusting the altitude h of an aircraft at its closest point of approach for the difference between airport altitude and altitude of the noise-sensitive area being considered.

ADDITIONAL CONSIDERATIONS FOR A NOISE ANALYSIS

1. Determine the Flight Track Utilization:

   Track utilization is defined as the proportion of operations in each direction along the flight track. Takeoff direction may well reverse during different periods of the day or year due to changes in wind direction or traffic needs. The flight track may differ for takeoff and landing operations. For example, the landing track will be straight in to the runway while the takeoff track may involve a turn after liftoff. Information on flight track utilization may be provided by the airport proprietor, FAA tower or traffic personnel, or FAA airports offices. Where detailed records are not available, estimates of track utilization may be obtained by studying wind rose information. Need for flight track information will be demonstrated in examples to follow.

2. Determine the approximate distribution of operations for day (7:00 a.m. - 7:00 p.m.), evening (7:00 p.m. - 10:00 p.m.), and night (10:00 p.m. - 7:00 a.m.) periods, local time.

   The average number of operations per day and the distribution during the day should be determined for each aircraft class under consideration, or for the "critical" noise aircraft. For most purposes, the number of operations over a one-year period may be used as the basis for determining the average number per day. In some cases, one may consider the aircraft activity levels for different

times of the year when pronounced changes in aircraft operations occur during different seasons.

Information on aircraft operations may be obtained from the Official Airline Guide, FAA tower personnel, airport personnel, or the airport proprietor.

The need for this information will be demonstrated in examples to follow.

## 3. Scope of Analysis with Different Classes of Aircraft.

The flight profile and noise tables included in this document represent most classes of aircraft. If jet operations represent greater than five percent of total operations, only jets need to be considered. A possible exception to this would be the case where a jet is replacing a piston type aircraft and one desires to quantify the noise impact before and after the introduction of the jets.

Several different models of a particular class of aircraft (e.g.: 727-100s, 727-200s) may operate from the same airport. For the purposes of these calculations, all models of a class of aircraft are considered identical.

## DEFINITIONS APPLICABLE TO THIS GUIDANCE MATERIAL

1. Noise-Sensitive Area - Noise-sensitive areas may include residential neighborhoods, educational, health, and religious structures and sites and outdoor recreational, cultural, and historic sites. A noise-sensitive area is generally defined as one in which aircraft noise may interfere with the normal activities associated with use of the land. Whether noise interferes with a particular use depends upon the level of noise exposure received and the type of activities involved. A site which is unacceptable for outside use may be acceptable for use inside a structure, if adequate noise attenuation features are built into that structure. Other areas may be noise sensitive, such as wildlife nesting areas or habitats.

2. Decibel (dB) - One tenth of a Bel. Sound is measured in decibels. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Decibels are not linear units, but are logarithmic. Thus, 100 decibels represent 10 billion times as much acoustic energy as one decibel.

3. Maximum A-Weighted Sound Level - The highest value in decibels, which is read from a sound-level meter, when the meter is switched to its weighting scale labeled "A". The value approximately measures the relative noisiness or annoyance level of many common sounds. (The human ear is less efficient at low and high sound frequencies than at medium or speech-range frequencies. In order to obtain a single

number for the level of a noise containing a wide range of frequencies, in a manner which represents the ear's response, it is necessary to reduce or weight the effects of the low and high frequencies with respect to the medium frequencies. The resultant sound level is said to be A-weighted, in units of A-weighted decibels, or dBA).

4. Sound Level Meter - An instrument, comprising a microphone, an amplifier, an output meter, and frequency-weighting networks, used for the measurement of noise and sound levels.

5. Ambient Noise - The totality of noise in a given place and time - usually a composite of sounds from varying sources at varying distances.

6. Effective Perceived Noise Level (EPNL) - A calculated measure designed to estimate more precisely the effective "noisiness" of a single noise event, usually an aircraft flyover; taking into account corrections for pure tones and for the duration of the noise.

## IMPACT OF NOISE ON PEOPLE

The term "noise" is defined by most people as unwanted sound. How people evaluate or judge the noisiness of a given sound depends on the physical characteristics of that sound and their aggregate emotional response to it.

### Physical Characteristics of Sound:

Physically, sound is a fluctuation in atmospheric pressure caused by disturbances which move through the air something like the ripples from a pebble dropped into a pond. Factors that make up the physical characteristics of sound include:

1. Intensity
2. Pitch (or frequency)
3. Time pattern (duration, repetition, and time of day)

### Intensity and Pitch:

The intensity of a sound (or sound pressure level) is the relative amount of sound energy radiating past a given point.

The intensity of sounds which are audible by the ear is commonly measured in decibels (abbreviated dB). On the decibel scale, 0 corresponds to the lowest sound level that the healthy, unimpaired human ear can detect.

However, this scale is logarithmic, and decibels are not like linear units such as miles or pounds. Each increase of 10 dB means that the acoustical energy is multiplied by 10. This means that a sound of 70 dB is 10 times as intense as 60 dB, 100 times as intense as 50 dB, and 1,000 times as intense as 40 dB.

The relative "loudness" of sounds, however, as perceived by the human ear, does not closely match the actual relative amounts of sound energy. For example, while 70 dB is physically 10 times as intense as 60 dB, listeners will tend to judge it as only twice as "loud."

The pitch (or frequency) of a sound depends on the relative rapidity of the vibrations by which it is produced. In a low-pitched tone the sound waves are repeated rather slowly, while in a high-pitched one the sound waves are repeated rapidly. Pitch is measured in cycles per second (called Hertz or Hz). Although pure-tone sounds contain only one frequency, most sounds are a mixture of different frequencies. Sound with a wide, random range of pitches is called "broad-band."

Although the human ear can hear frequencies as low as 20 Hz and as high as 15,000 Hz, it does not hear them all equally well. This means that people may assign different "loudnesses" to two sounds having identical intensities but widely differing frequencies. To compensate for this tendency, various adaptations of the basic decibel scale have been

devised. The most widely used is the "A-weighted sound pressure level", which is measured in A-weighted decibels -- or dBA. This measurement can be made directly by standard sound level meters, which electronically weight the sound intensities at different frequency ranges so as to discriminate against those ranges which the ear hears less well.

Table 1 lists some typical examples of sound in dBA. Its righthand column suggests how people will tend to judge the relative "loudness" of these sounds.

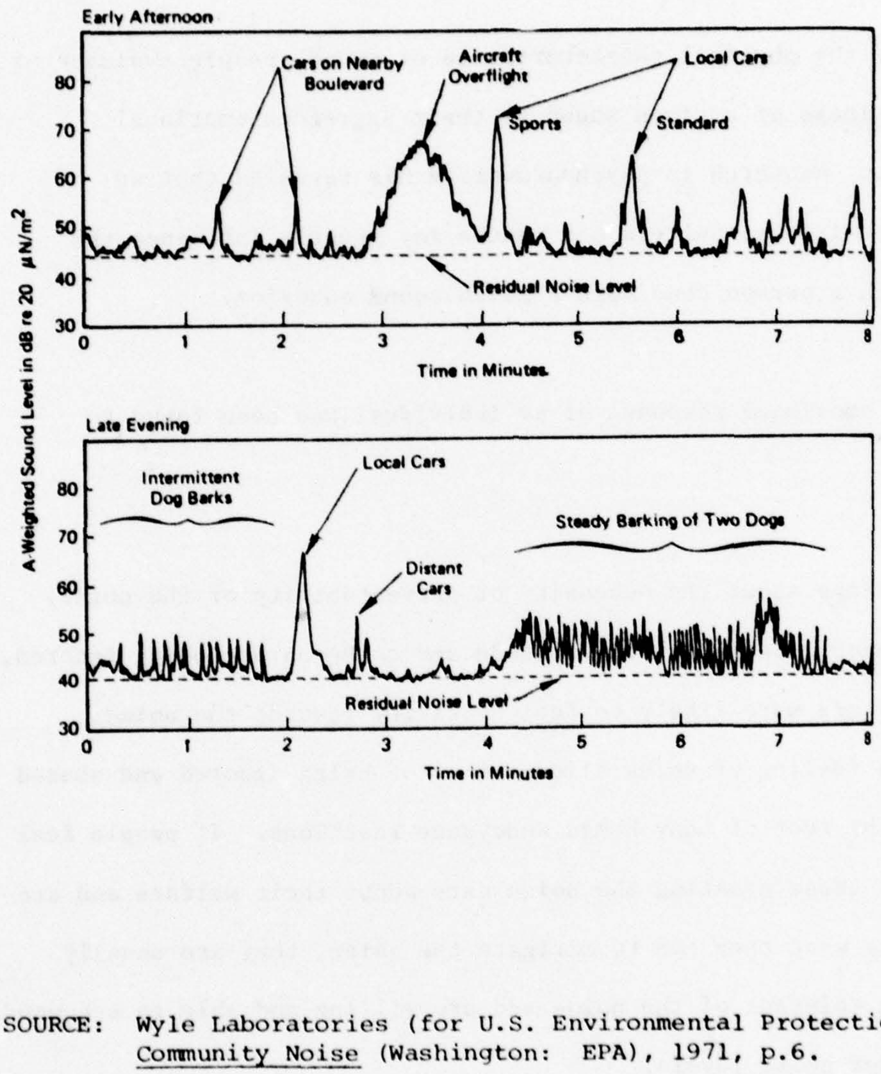
Time Pattern:

Sounds also differ in temporal patterns. A sound may be short or long-lasting, it may be steady, repetitive, or intermittent, and it may occur during the busy day or the quietness of nighttime.

Over any given time period, the overall sound level constantly fluctuates as various individual noise events occur. This can be illustrated, as in Figure 3, by a continuous graphic level recording analogous to those used with seismographs. Figure 3 also illustrates the way individual noise peaks tend to be superimposed over a residual or ambient noise level, which is more or less stable at any given location at any given hour. This residual level can be described as the sound which is the pervasive sound level remaining after all identifiable individual sounds are eliminated.

FIGURE 3

TWO SAMPLES OF OUTDOOR NOISE
IN A NORMAL SUBURBAN NEIGHBORHOOD
WITH THE MICROPHONE LOCATED 20 FEET
FROM THE STREET CURB




SOURCE: Wyle Laboratories (for U.S. Environmental Protection Agency) Community Noise (Washington: EPA), 1971, p.6.

Sharp increases in sound pressure level above the ambient level, especially sound levels reaching a high peak very abruptly, are usually perceived to be very annoying.

Emotional Response to Sound:

In addition to the physical characteristics of sound, people evaluate or judge the noisiness of a given sound by their aggregate emotional response to it. Research in psychoacoustics has revealed that an individual's attitudes, beliefs and values may greatly influence the degree to which a person considers a given sound annoying.

The aggregate emotional response of an individual has been found to depend on:

a. Feelings about the necessity or preventability of the noise. If people feel that their needs and concerns are being ignored, they are more likely to feel hostility towards the noise. This feeling of being alienated or of being ignored and abused is the root of many human annoyance reactions. If people feel that those creating the noise care about their welfare and are doing what they can to mitigate the noise, they are usually more tolerant of the noise and are willing and able to accommodate higher noise levels.

b. Judgment of the importance and of the value of the primary function of the activity which is producing the noise.

c. Activity at the time an individual hears a noise and the disturbance experienced as a result of the noise intrusion. An individual's sleep, rest and relaxation have been found to be more easily disrupted by noise than his communication and entertainment activities.

d. Attitudes about environment. The existence of undesirable features in a person's residential environment will influence the way in which he reacts to a particular intrusion.

e. General sensitivity to noise. People vary in their ability to hear sound, their physiological predisposition to noise and their emotional experience of annoyance to a given noise.

f. Belief concerning the effect of noise on health.

g. Feeling of fear associated with the noise. For instance, the extent to which an individual fears physical harm from the source of the noise will affect his attitude toward the noise.

The existence of these many physical and emotional variables makes it impossible to predict accurately how any one individual will respond to a given noise. However, considering the community as a whole, trends emerge which relate noise to annoyance.

TABLE 1

SOUND LEVELS (dBA) AND LOUDNESS OF ILLUSTRATIVE NOISES
IN INDOOR AND OUTDOOR ENVIRONMENTS

**Sound Levels and Loudness of Illustrative Noises in Indoor and Outdoor Environments**
(A-Scale Weighted Sound Levels )

| dB(A) | OVER-ALL LEVEL (Sound Pressure Level Approx. 0.0002 Microbar) | COMMUNITY (Outdoor) | HOME OR INDUSTRY (Indoor) | LOUDNESS (Human Judgment of Different Sound Levels) |
|---|---|---|---|---|
| 130 | | | | |
| 120 | UNCOMFORTABLY | Military Jet Aircraft Take-Off With After-Burner From Aircraft Carrier @ 50 Ft. (130) | Oxygen Torch (121) | 120 dB(A) 32 Times As Loud |
| 110 | LOUD | Turbo-Fan Aircraft @ Take-Off Power @ 200 Ft. (118) | Riveting Machine (110)<br>Rock-N-Roll Band (108-114) | 110 dB(A) 16 Times As Loud |
| 100 | VERY | Jet Flyover @ 1000 Ft. (103)<br>Boeing 707, DC-8 @ 6080 Ft. Before Landing (106)<br>Bell J-2A Helicopter @ 100 Ft. (100) | | 100 dB(A) 8 Times As Loud |
| 90 | LOUD | Power Mower (96)<br>Boeing 737, DC-9 @ 6080 Ft. Before Landing (97)<br>Motorcycle @ 25 Ft. (90) | Newspaper Press (97) | 90 dB(A) 4 Times As Loud |
| 80 | | Car Wash @ 20 Ft. (89)<br>Prop. Plane Flyover @ 1000 Ft. (88)<br>Diesel Truck, 40 MPH @ 50 Ft. (84)<br>Diesel Train, 45 MPH @ 100 Ft. (83) | Food Blender (88)<br>Milling Machine (85)<br>Garbage Disposal (80) | 80 dB(A) 2 Times As Loud |
| 70 | MODERATELY LOUD | High Urban Ambient Sound (80)<br>Passenger Car, 65 MPH @ 25 Ft. (77)<br>Freeway @ 50 Ft. from Pavement Edge, 10 A.M. (76 ± 6) | Living Room Music (76)<br>TV-Audio, Vacuum Cleaner (70) | 70 dB(A) |
| 60 | | Air Conditioning Unit @ 100 Ft. (60) | Cash Register @ 10 Ft. (65-70)<br>Electric Typewriter @ 10 Ft. (64)<br>Dishwasher (Rinse) @ 10 Ft. (60)<br>Conversation (60) | 60 dB(A) ½ As Loud |
| 50 | QUIET | Large Transformers @ 100 Ft. (50) | | 50 dB(A) ¼ As Loud |
| 40 | | Bird Calls (44)<br>Lower Limit, Urban Ambient Sound (40) | | 40 dB(A) ⅛ As Loud |
| 10 | JUST AUDIBLE | [dB(A) Scale Interrupted] | | |
| 0 | THRESHOLD OF HEARING | | | |

Source: Melville C. Branch, et al., Outdoor Noise and the Metropolitan Environment, (Los Angeles: Department of City Planning, 1970), p. 2

Table 1 lists for different sound levels in dBA the loudness of illustrative noises in typical outdoor and indoor environments. Table 2 provides information on the noise reduction provided by a building. Values selected from this table depend on the season of the year and geographical location under consideration. As an example, a home with storm windows located in Maine would offer a 25 dB noise reduction during the winter. The same home may offer a 10 dB reduction in noise during the summer if most of the windows are open. Table 3 provides information on the impact of increasing sound levels on speech. This table provides outdoor interference levels. Indoor interference levels can be determined by reducing the sound level in Table 3 by the amount of noise reduction determined from Table 2.

The information provided in these tables along with an evaluation of the characteristics of the community under consideration should enable one to predict reasonably well the community response to a given change in sound level. The characteristics to consider for the community being studied include:

a. Type of neighborhood - instances of annoyance, disturbances and complaint associated with a particular noise exposure will be greatest in rural areas, followed by suburban and urban residential areas, and then commercial and industrial areas in decreasing order. The type of neighborhood may actually be associated with one's expectations regarding noise. People

TABLE 2

NOISE REDUCTION PROVIDED BY A BUILDING

| BUILDING TYPE | WINDOW CONDITION | NOISE REDUCTION DUE TO BUILDING STRUCTURE (dB) |
|---|---|---|
| ALL | OPEN | 10 |
| LIGHT FRAME | ORDINARY SASH | |
| | CLOSED | 20 |
| | WITH STORM WINDOWS | 25 |
| MASONRY | SINGLE GLAZED | 25 |
| | DOUBLE GLAZED | 35 |

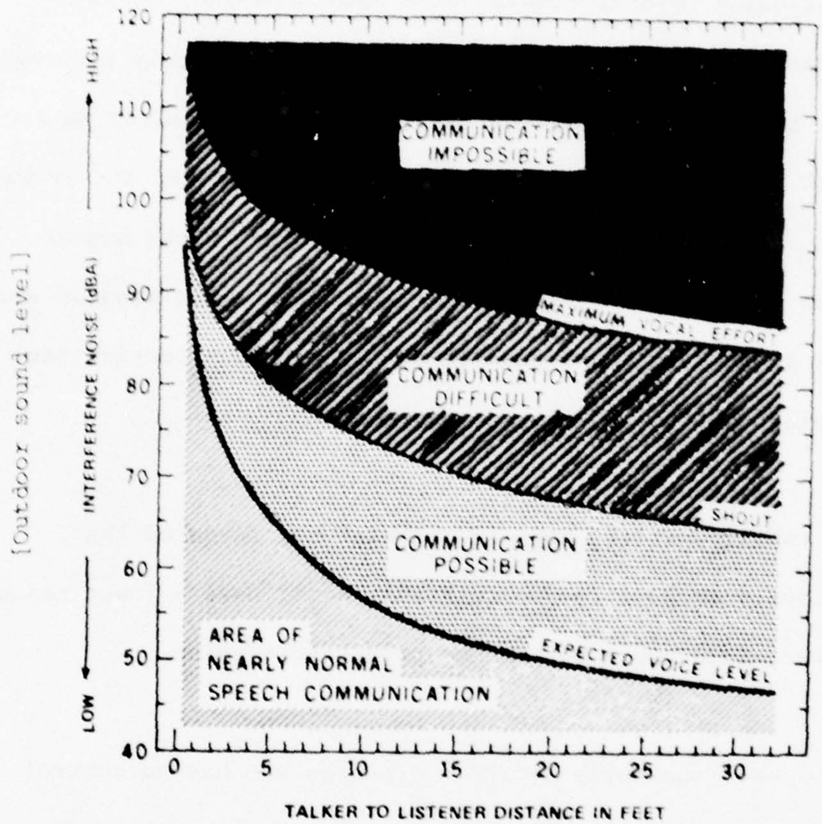
ALTERNATIVE MEANS TO ESTIMATE REDUCTION INSIDE A BUILDING

| PERCENT OF EXTERIOR WALL HAVING OPEN WINDOWS | APPROXIMATE NOISE REDUCTION |
|---|---|
| 1% | 17 dB |
| 2% | 14 dB |
| 4% | 11 dB |
| 8% | 8 dB |
| 16% | 5 dB |
| 32% | 2 dB |
| 50% | 0 dB |

Source: Fundamentals and Abatement of Highway Traffic Noise - U.S. Department of Transportation.

TABLE 3

SPEECH INTERFERENCE LEVELS




Source: Report to the President and Congress on Noise - 1972.

expect rural neighborhoods to be quieter than cities. Consequently, a given noise exposure may produce greater negative reaction in a rural area.

b. Time of day - several studies have indicated that noise intrusions are considered more annoying in the early evening and at night than during the day, because of about 10 dB lower ambient levels at night and interference with sleep and TV watching.

c. Season - noise is considered more disturbing in the summer than in the winter. This is understandable since windows are likely to be open in the summer and recreational activities take place out of doors.

d. Predictability of the noise - research has revealed that individuals exposed to unpredictable noise have a lower noise tolerance than those exposed to predictable noise.

e. Control over the noise source - a person who has no control over the noise source will be more annoyed than one who is able to exercise some control.

f. Length of time an individual is exposed to a noise - there is little evidence supporting the argument that annoyance resulting from noise will decrease with continued exposure; rather, under some circumstances, annoyance may increase the longer one is exposed.

## Noise Descriptors:

There are two general methods available to describe noise impact resulting from aircraft operations. The first involves those descriptors that characterize a single event such as an aircraft takeoff or landing. The second involves those descriptors that characterize the total noise impact of numerous single events (e.g., takeoffs and landings over a 24-hour period). This guidance material only considers the maximum sound level of single aircraft events.

The individual noise events of most concern are generated by aircraft "flyovers" during takeoffs and landings. The typical flyover noise signal may be characterized in time as a "haystack" shaped graph (noise level vs time) that rises from a lower ambient noise level and increases to a maximum over a period of seconds and then decreases to merge once more with the background noise. This is depicted in Figure 4. This document attempts to determine the maximum sound level in dBA for individual aircraft events.

## Differences in Ambient Sound Levels Between Areas:

As one would expect, there are enormous differences between the noise patterns at different locations. Figure 5, taken from a national study, shows percentile measurements of the daytime outdoor noise levels in a sample of widely varying settings.

FIGURE 4

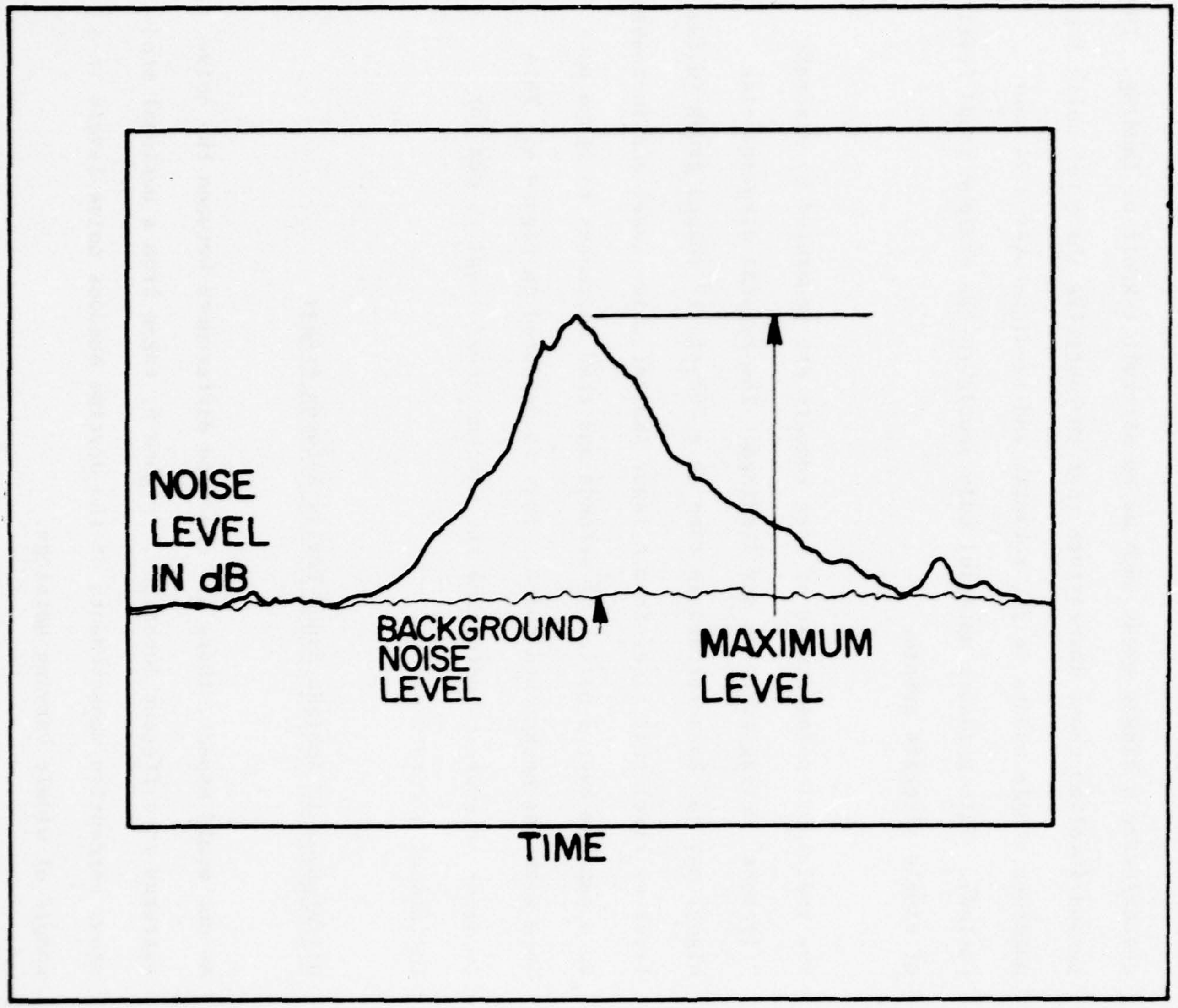
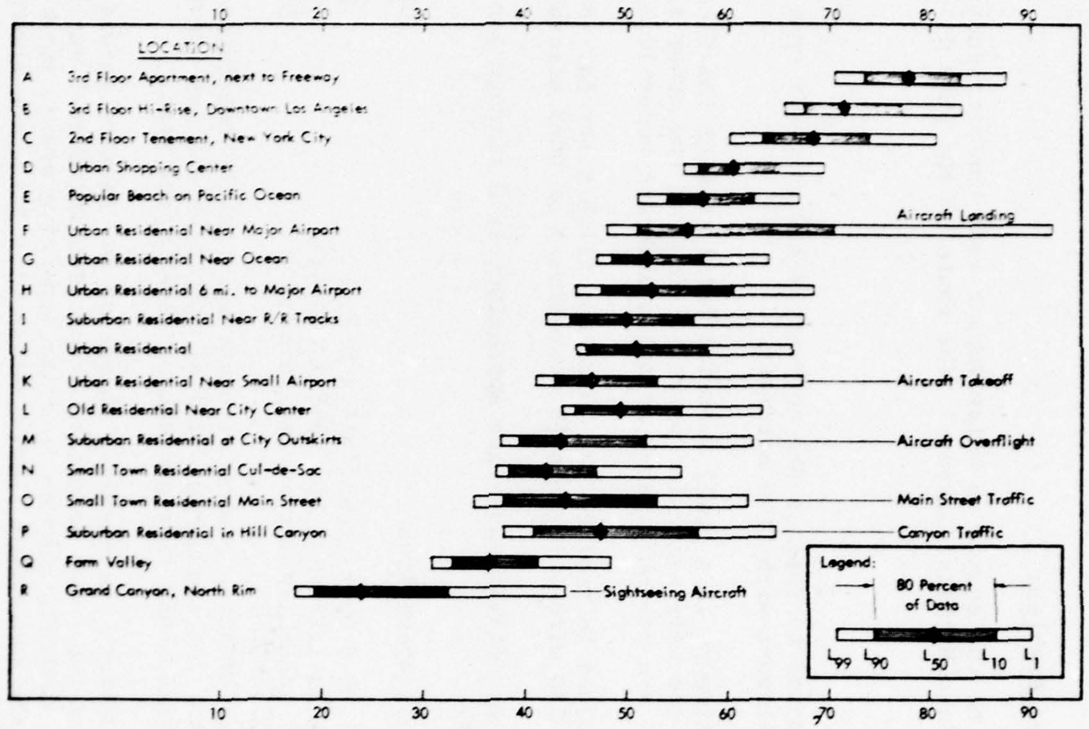

NOISE
LEVEL
IN dB
BACKGROUND
NOISE
LEVEL
MAXIMUM
LEVEL
TIME

FIGURE 5

DAYTIME OUTDOOR NOISE LEVELS FOUND IN 18 LOCATIONS RANGING BETWEEN THE WILDERNESS AND THE DOWNTOWN CITY, WITH SIGNIFICANT INTRUDING SOURCES NOTED[1]




[1]Data are arithmetic averages of the 12 hourly values in the daytime period (7:00 a.m. - 7:00 p.m.) of the levels which are exceeded 99, 90, 50, 10, and 1 per cent of the time.

Source: Wyle Laboratories (for U.S. Environmental Protection Agency), Community Noise, (Washington: EPA) 1971, p. 18.

## CASE STUDY - FLIGHT STANDARDS

Operating Specification for the Introduction of DC-9 Aircraft into an

Airport -

Statement of the Problem:

What will be the change in noise impact with the introduction of DC-9 aircraft into Mythical Airport? The route of the DC-9 will be less than 500 NM.

Given:

1. It is proposed to replace the current CV-580 aircraft that serve Mythical Airport with DC-9 aircraft.

2. Mythical Airport is a small suburban facility with the CV-580 providing the only scheduled service. Most of the other aircraft operations are piston general aviation aircraft under 12,500 lbs.

   It is proposed to replace the current 4 flights per day (8 operations) by the CV-580 with 4 flights (8 operations) of DC-9 aircraft.

   Business jet activity averages approximately 3 flights per day (6 operations).

| | |
|---|---|
| Total annual operations | 100,000 |
| Annual DC-9 Operations (365 x 8 Ops) | 2,920 |
| Annual Business Jet Ops (365 x 6 Ops) | 2,190 |
| Annual General Aviation Piston a/c | 94,890 |

3. The general aviation piston aircraft will not be considered because jet aircraft are the noise critical operation and jet operations number greater than five percent of total operations.

4. Figure 6 depicts the physical layout of the airport runway, flight tracks, and two noise sensitive areas identified as P and Q. If land use plans indicate changes in noise sensitive areas, this change should be added to the assessment. Coordination with land use authorities may also be pertinent.

5. Flight Track Utilization

   The morning DC-9 arrival will land using Track 27B and depart on Track 09A. The remaining DC-9 flights land using Track 09A and depart on Track 27A. The CV-580 has the same flight track utilization as the DC-9. The business jets (Learjet) land using Track 09A and depart on Track 27B. Typical flight tracks are used here which may be an over-simplification.

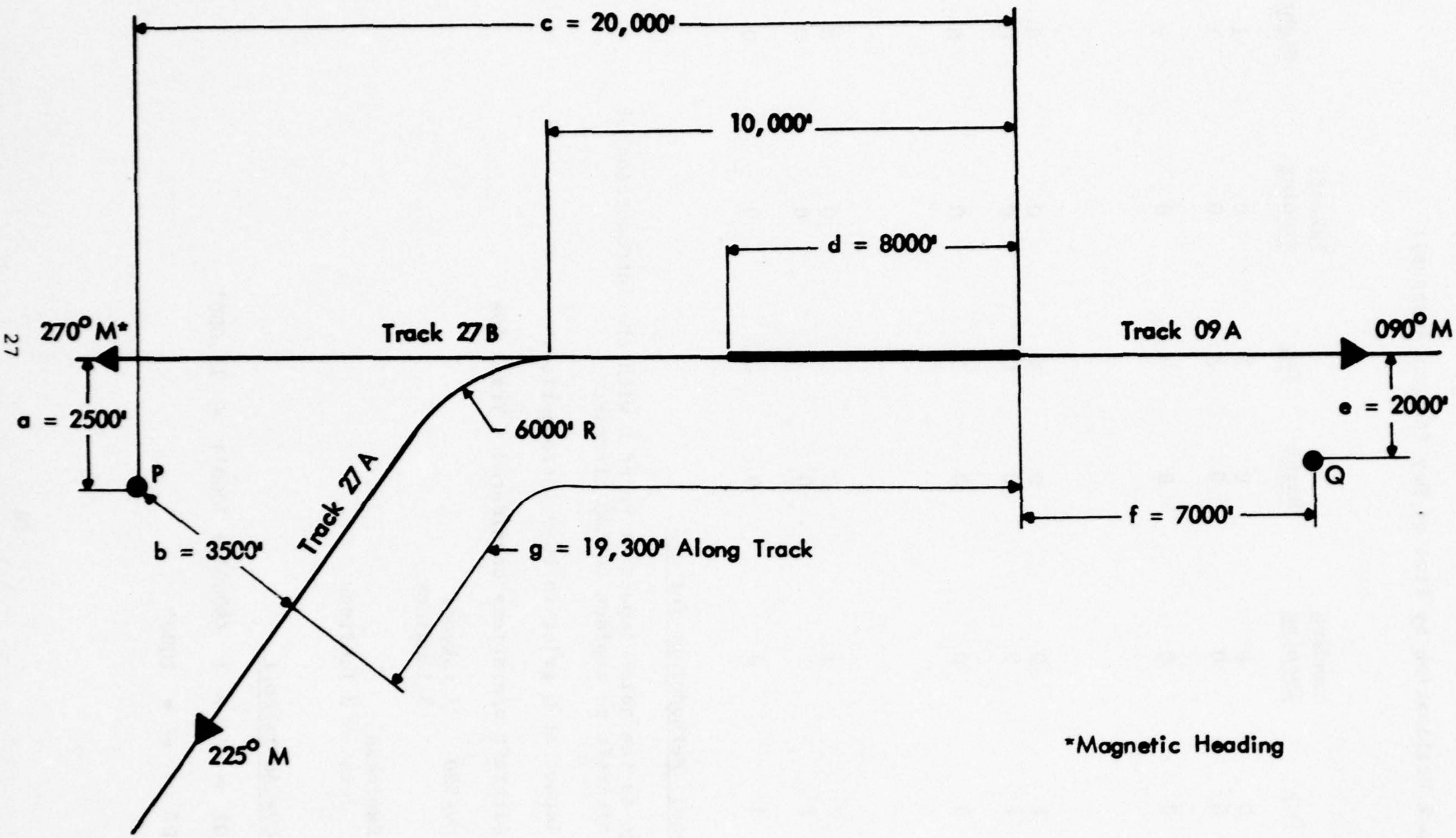



FIGURE 6. EXAMPLE: FLIGHT TRACKS AT MYTHICAL AIRPORT

Flight Track Utilization by Time of Day (Annual Average):

Track 27A

| | Landing Day | Landing Evening | Landing Night | Takeoff Day | Takeoff Evening | Takeoff Night |
|---|---|---|---|---|---|---|
| DC-9 | 0 | 0 | 0 | 2 | 0 | 1 |
| CV-580 | 0 | 0 | 0 | 2 | 0 | 1 |
| Business Jets | 0 | 0 | 0 | 0 | 0 | 0 |

Track 27B

| | Landing Day | Landing Evening | Landing Night | Takeoff Day | Takeoff Evening | Takeoff Night |
|---|---|---|---|---|---|---|
| DC-9 | 1 | 0 | 0 | 0 | 0 | 0 |
| CV-580 | 1 | 0 | 0 | 0 | 0 | 0 |
| Business Jets | 0 | 0 | 0 | 3 | 0 | 0 |

Track 09A

| | Landing Day | Landing Evening | Landing Night | Takeoff Day | Takeoff Evening | Takeoff Night |
|---|---|---|---|---|---|---|
| DC-9 | 2 | 1 | 0 | 1 | 0 | 0 |
| CV-580 | 2 | 1 | 0 | 1 | 0 | 0 |
| Business Jets | 3 | 0 | 0 | 0 | 0 | 0 |

Calculations: Methodology for dBA

1. Change in the noise impact at Point Q with the introduction of DC-9 aircraft to replace CV-580 aircraft.

   a. Impact at Q prior to DC-9 introduction.

      Aircraft operations considered - Track 09A

      CV-580 1 takeoff
      3 landings

      Business Jets 3 landings

      CV-580 Takeoff

      D1 = d + f (8000' + 7000') = 15,000'

      D2 = e = 2000'

Consult Profile Chart (Figure 19) for h

h = 1050'

Compute Slant Range Distance S

$$S = \sqrt{(2000)^2 + (1050)^2}$$

S = 2259'

Consult Noise Table 10 for dBA value of CV-580

Maximum Sound Level = 82 dBA

<u>CV-580 Landing</u>

$D_1 = f = 7000'$

$D_2 = e = 2000'$

Consult Profile Chart (Fiqure 11) for landing*

h = 420'

Compute Slant Range Distance S

$$S = \sqrt{(2000)^2 + (420)^2}$$

S = 2044'

Consult Noise Table 10 for dBA value of CV-580

Maximum Sound Level = 72 dBA

* Or calculate approach elevation simply

$$h = (D_1 + 1000) \tan 3^\circ$$
$$= 0.0524\ (D_1 + 1000) \text{ feet}$$

Business Jet Landing (Learjet)

$D_1 = f = 7000'$

$D_2 = e = 2000'$

Consult Profile Chart (Figure 11) for Learjet landing profile for h
h = 420'

Compute Slant Range Distance S

$S = \sqrt{(2000)^2 + (420)^2}$
$S = 2044'$

Consult Noise Table 11 for dBA value of LearJet.

Maximum Sound Level = 77 dBA

b. Impact at Q with DC-9 introduction.

Aircraft Operations Considered - Track 09A

| | |
|---|---|
| DC-9 | 1 takeoff |
| | 3 landings |
| LearJet | 3 landings |

DC-9 Takeoff

$D_1 = (d + f) = 15{,}000'$
$D_2 = e = 2000'$

Consult Profile Chart (Figure 12) for DC-9 takeoff profile

for altitude measure

Range less than 500 NM

h = 1200'

Compute slant range distance S

$$S = \sqrt{(1200)^2 + (2000)^2}$$
$$S = 2332'$$

Consult Noise Table 4 for dBA value for DC-9 takeoff.

Maximum sound level in dBA for DC-9 takeoff at Point Q = 89 dBA

DC-9 Landing

$D_1 = f = 7000'$

$D_2 = e = 2000'$

Consult Profile Chart (landing profile, Figure 11) h=420'

Compute S

$$S = \sqrt{(420)^2 + (2000)^2}$$
$$S = 2044'$$

Consult Noise Table 4 for dBA value for DC-9 landing

Maximum sound level in dBA for landing of DC-9 = 77 dBA

Learjet Landing

77 dBA (from previous calculation)

Summary of Change in Noise Impact of Point Q

The introduction of the DC-9 will result in an increase in noise at point Q. **This increase will be limited to 3 additional** landings (2 during the day and 1 in the evening) and 1 takeoff. The sound level of the DC-9 landing will be 77 dBA or equal to that of the existing Learjet. The sound level of the DC-9 takeoff will be approximately 89 dBA. This one daily operation will be the most noise critical. It will be perceived as more than twice as noisy as the DC-9 or Learjet landings. The appendix of this guidance will provide information on the impact of noise on people. The DC-9 will be perceived as more noisy than the CV-580 takeoff.

FIGURE 7

Noise Exposure at Point Q
with Introduction of DC-9

| BEFORE | Takeoff (day) | | Landing (night) | | Landing (evening) | |
|---|---|---|---|---|---|---|
| | Number Operations | Noise Level | Number Operations | Noise Level | Number Operations | Noise Level |
| CV-580 | 1 | 82 dBA | 2 | 72 dBA | 1 | 72 dBA |
| Learjet | 0 | - | 3 | 77 dBA | 0 | - |

| AFTER | Takeoff (day) | | Landing (day) | | Landing (evening) | |
|---|---|---|---|---|---|---|
| | Number Operations | Noise Level | Number Operations | Noise Level | Number Operations | Noise Level |
| DC-9 | 1 | 89 dBA | 2 | 77 dBA | 1 | 77 dBA |
| Learjet | 0 | - | 3 | 77 dBA | 0 | - |

NOTE: If increases in air traffic for the noisier aircraft are projected, this chart and explanatory text should be expanded to describe the effect of the increase.

2. Change in noise impact at point P with the introduction of DC-9 aircraft to replace CV-580 aircraft.

a. Impact at P prior to DC-9 introduction.

Aircraft operations considered - Tracks 27A and 27B

CV-580 3 takeoffs
1 landing

Learjet 3 takeoffs

CV-580 Takeoff

$D_1 = g = 19,300'$

$D_2 = b = 3500'$

Consult Profile Chart (Figure 19) for h

h = 1400'

Compute Slant Distance S

$S = \sqrt{(3500)^2 + (1400)^2}$

S = 3770'

Consult Noise Table 10 for dBA value of CV-580. Maximum Sound Level = 77 dBA

CV-580 Landing

$D_1 = 20,000 - 8,000' = 12,000'$

$D_2 = 2500'$

Consult Profile Chart (Figure 11) - h = 680'

Compute Slant Distance S

$S = \sqrt{(2500)^2 + (680)^2}$
S = 2590'

Consult Noise Table 10 for dBA value of CV-580 landing
Maximum Sound Level = 70 dBA

Learjet Takeoff

$D_1 = 20,000'$

$D_2 = 2500'$

Consult Profile Chart (Figure 19) - h = 2500'

Compute Slant Distance S $\quad S = \sqrt{(2500)^2 + (2500)^2}$

$S = 3536'$

Consult Noise Table 11 for dBA value for takeoff Maximum sound level = 85 dBA.

b. Impact at P after DC-9 introduction.

Aircraft operations considered - Tracks 27A and 27B

| | |
|---|---|
| DC-9 | 3 takeoffs<br>1 landing |
| Business Jet | 3 takeoffs |

DC-9 Takeoff

$D_1 = g = 19{,}300'$

$D_2 = b = 3{,}500'$

Consult Profile Chart(Figure 12) for h

$h = 1750'$

$S = \sqrt{(1750)^2 + (3500)^2}$

$S = 3913'$

Maximum sound level = 81 dBA

Note: The altitude (h value) is over 1500 feet. However, we have determined to evaluate the worst case and used takeoff thrust of 12,000 lbs. (Noise Table 4).

FIGURE 8

Noise Exposure at Point P
with Introduction of DC-9

BEFORE

| | Takeoff (day) | | Takeoff (night) | | Landing (day) | |
|---|---|---|---|---|---|---|
| | Number Operations | Noise Level | Number Operations | Noise Level | Number Operations | Noise Level |
| CV-580 | 2 | 77 dBA | 1 | 77 dBA | 1 | 70 dBA |
| Learjet | 3 | 85 dBA | 0 | - | 0 | - |

AFTER

| | Takeoff (day) | | Takeoff (night) | | Landing (day) | |
|---|---|---|---|---|---|---|
| | Number Operations | Noise Level | Number Operations | Noise Level | Number Operations | Noise Level |
| DC-9 | 2 | 81 dBA | 1 | 81 dBA | 1 | 74 dBA |
| Learjet | 3 | 85 dBA | 0 | - | 0 | - |

NOTE: If increases in air traffic for the noisier aircraft are projected, this chart and explanatory text should be expanded to describe the effect of the increase.

DC-9 Landing

$D_1 = 12{,}000'$

$D_2 = 2{,}500'$

Consult Profile Chart (Figure 11) for h

$h = 680'$

$$S = \sqrt{(680)^2 + (2500)^2}$$

$S = 2590'$

Consult Noise Table 4

Maximum Sound Level = 74 dBA

Analysis - Impact of the DC-9 on Noise Sensitive Areas P and Q in the Vicinity of Mythical Airport

Mythical Airport is located in a suburban location at the outskirt of a medium-size city. Noise sensitive areas P and Q are suburban residential neighborhoods of medium income families. There has been only an occasional noise complaint from these neighborhoods because of aircraft operations from the airport. The ambient noise level for these neighborhoods is estimated at between 40 and 60 dBA (Figure 5). Table 1 indicates that a 40 to 60 dBA sound level is relatively quiet and acceptable to most people.

Prior to the introduction of the DC-9, the LearJet operations represent the noisiest operation at Mythical Airport. The three daily landings cause a maximum sound level at noise-sensitive area Q of approximately 77 dBA (outdoor).

The three daily Learjet takeoffs cause a maximum sound level at noise-sensitive area P of 85 dBA. Table 1 indicates that this sound level is loud to most people and is approximately equal to the sound level a person would experience standing 50 feet from a diesel truck traveling 40 mph. However, this sound level occurs only three times a day, and lasts only a few seconds for each aircraft event (Figure 4). Finally, depending upon the season of the year, the houses would reduce this maximum sound level to people indoors by approximately 10 to 20 dB (Table 2).

The DC-9 would be the most noise critical operation for noise-sensitive area Q. The DC-9 takeoffs would be perceived as more noisy than the CV-580 takeoff. At area Q, the single daily DC-9 takeoff would have a maximum sound level of 89 dBA (outdoors). Table 1 indicates that most people would judge this sound level as loud. However, this sound level would occur only once during a day for only a few seconds in duration. The maximum sound level experienced indoors by this takeoff would be 70 or 80 dBA depending on the season of the year (Table 2). Table 3 indicates that communication between two people would be difficult outdoors during the few seconds when the maximum sound level occurs. People indoors with a 10 to 20 dBA reduction of this maximum sound level would be able to communicate with a raised voice if the distance between talker and listener did not exceed 5 or 10 feet. At distances greater, people would find communication difficult and would be required to shout.

At area P, the DC-9 nighttime takeoff would be the most noise critical operation with a maximum sound level of approximately 81 dBA. Table 1 indicates that this sound level would be moderately loud for most people. The night takeoff would be more critical than the daytime takeoff of the same sound level because people usually judge noises to be more annoying at night as compared to the daytime hours. One reason for this is the fact that the ambient level of the neighborhood would be lower at night as compared to the daytime hours. The greater difference between the ambient sound level at night and the maximum sound level of the DC-9 takeoff would make the night takeoff more noticeable as compared to the daytime takeoff. Note that the Learjet takeoff has as high a noise level as the DC-9 (85 dBA vs. 81 dBA). However, it may be difficult for most people to distinguish which aircraft is more noisy.

Conclusions:

The DC-9 will be the most noise critical operation at Mythical Airport. However, the small number of daily flights(four flights per day) should not alter significantly the noise environment in the residential neighborhoods P and Q. The most noise critical operations will be the morning DC-9 takeoff past noise-sensitive area Q and the night DC-9 takeoff past noise sensitive area P.

The morning DC-9 takeoff past point Q will be perceived by most people as more noisy than the existing CV-580 takeoff. This morning DC-9 takeoff will be a noticeable change for most people. The DC-9 operations past point P will be perceived as noisy as the existing Learjet operations. The nighttime DC-9 takeoff will be the most noise

critical operation, because of sleep or TV interference, at a time when ambient noise levels are about 10 dB lower than in daytime. Finally, the number of jet operations will more than double with the introduction of the DC-9 (6 Learjet plus 8 DC-9 operations per day). This may prove to be an irritation to some people.

## CASE STUDY - AIR TRAFFIC

Establishment of a New Jet Departure Flight Track -

Statement of the Problem:

What will be the change in noise impact at an identified noise-sensitive area with the establishment of a new jet departure flight track and the shifting of all departing jet traffic to the new flight track from an existing flight track?

Given:

1. It is proposed to establish a new jet departure flight track (B) at Golden State Municipal Airport. See Figure 9. It is also proposed to shift all jet departures from flight track (A) to the new flight track (B).

2. The land parcel identified in Figure 9 is a noise-sensitive urban neighborhood consisting of medium income families. Golden State Municipal Airport is a medium size air carrier airport.

3. Jet aircraft make up 20 percent of total airport operations and therefore general aviation piston operations will not be considered.

4. Landing operations will not be considered because jet takeoffs are the noise-critical operation. 90 percent of all jet departures (annual average) currently use flight track (A). Less than 10 percent of all landing operations (annual average) occur on flight track (C).

5. Aircraft types considered and average daily departures on flight track (A) by time of day.

| Aircraft | Range | Day | Evening | Night | Total |
|---|---|---|---|---|---|
| 707-120B | (1500 NM) | 1 | 1 | | 2 |
| 727-200 | (700 NM) | 24 | 3 | 3 | 30 |
| DC-9-30 | (450 NM) | 6 | 1 | 2 | 9 |
| Learjet | | 4 | | 1 | 5 |
| | | | | | 46 |

Day (7:00 a.m. - 7:00 p.m.)
Evening (7:00 p.m. - 10:00 p.m.)
Night (10:00 p.m. - 7:00 a.m.)

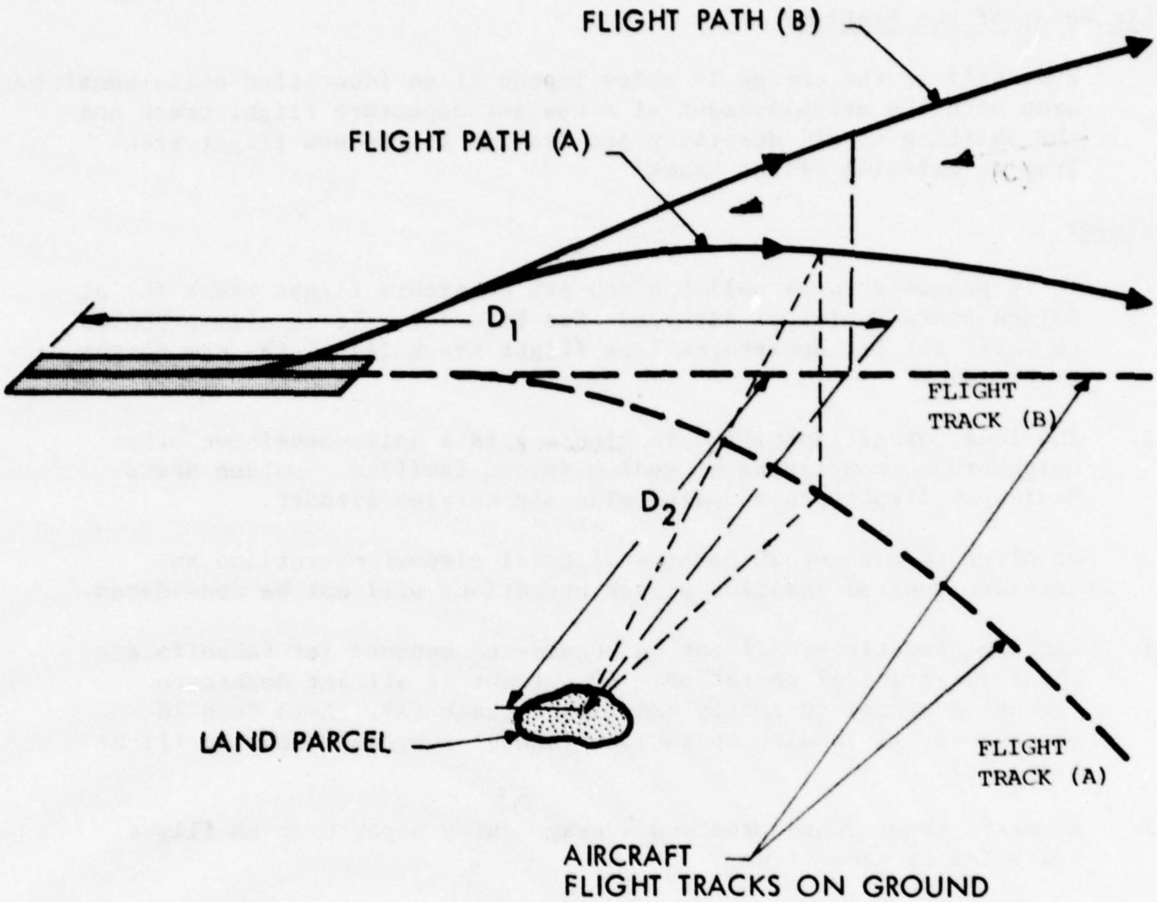



FIGURE 9. NEW FLIGHT TRACK FOR TAKEOFF

6. Flight track (A) - $D_1$ = 16,000 feet $D_2$ = 1,000 feet

Flight tract (B) - $D_1$ = 12,000 feet $D_2$ = 3,000 feet

There has been a long history of noise complaints from the land parcel shown in Figure 9. In fact, the primary reason for this proposed action is noise complaints.

Planned changes in land use should also be considered in assessing the effort on noise sensitive areas. Coordination with land use authorities may also be pertinent.

Calculations:

1. Maximum Sound Level in dBA at the land parcel with jet aircraft using flight track (A).

   $D_1$ for all aircraft on flight track (A) = 16,000 feet

   $D_2$ for all aircraft on flight track (A) = 1,000 feet

   Consult Profile Charts for altitude h:

   707-120B h = 1200' (Figure 15)

   727-200 h = 975' (Figure 14)

   DC-9-30 h = 1360' (Figure 12)

   Learjet h = 1800' (Figure 18)

   Calculate slant range distance S:

   707-120B - $S = \sqrt{1200)^2 + (1000)^2} = 1562'$

   727-200 - $S = \sqrt{(975)^2 + (1000)^2} = 1397'$

   DC-9-30 - $S = \sqrt{(1360)^2 + (1000)^2} = 1688'$

   Learjet - $S = \sqrt{(1800)^2 + (1000)^2} = 2059'$

Consult Noise Tables for dBA value.

Maximum Sound Level

| | | |
|---|---|---|
| 707-120B = 99 dBA | (conservative calculation) | (Table 7) |
| 727-200 = 98 dBA | | (Table 6) |
| DC-9-30 = 93 dBA | | (Table 4) |
| Learjet = 92 dBA | | (Table 11) |

Therefore, the current most noise-critical operation for the land parcel under consideration are the two 707-120B departures each day. However, the 727-200 departures will be perceived as almost equally as noisy, while the Learjet and the DC-9 may be perceived as less noisy.

2. Maximum Sound Level in dBA at the Land Parcel with aircraft using flight track (B)

$D_1$ = 12,000 feet

$D_2$ = 3,000 feet

Consult Profile Chart for altitude h

707-120B = 700'

727-200 = 500'

DC-9-30 = 850'

Learjet = 1150'

Calculate slant range distance S

707-120B - S = $\sqrt{(700)^2 + (3000)^2}$ = 3081'

727-200 - S = $\sqrt{(500)^2 + (3000)^2}$ = 3041'

DC-9-30 - S = $\sqrt{(850)^2 + (3000)^2}$ = 3118'

Learjet - S = $\sqrt{(1150)^2 + (3000)^2}$ = 3213'

FIGURE 10

IMPACT OF ESTABLISHMENT OF
NEW JET DEPARTURE FLIGHT TRACK

| | Before | After |
|---|---|---|
| B-707 | 99 dBA | 90 dBA |
| B-727 | 98 dBA | 89 dBA |
| DC-9 | 93 dBA | 85 dBA |
| Learjet | 92 dBA | 87 dBA |

NOTE: If increases in air traffic for the noisier aircraft are projected, this chart and explanatory text should be expanded to describe the effect of the increase.

Consult Noise Table for dBA value
Maximum Sound Level

| | | |
|---|---|---|
| 707-120 | = | 90 dBA |
| 727-100 | = | 89 dBA |
| DC-9-30 | = | 85 dBA |
| Learjet | = | 87 dBA |

Analysis - Impact of the Establishment of a New Jet Departure Flight Track

The establishment of flight track (B) and the shift of all jet departures from flight track (A) to (B) will result in a reduction of 5 to 9 dBA for jet aircraft. This will be perceived as a reduction of noise at the land parcel by approximately one-half.

The ambient noise level at the noise sensitive land parcel is estimated at between 52-77 dBA (Figure 5, line F). Table 1 indicates that this sound level ranges from quiet to moderately loud. The low range (below 50 dBA) would most likely occur at night and the moderately loud sound level during the day.

Prior to the establishment of the new departure flight track, the noise sensitive land parcel was exposed to numerous aircraft events each day with a maximum sound level for departing jets ranging between 99 dBA and 92 dBA. Table 1 indicates that this sound level is loud to very loud and most likely not acceptable to most people. This neighborhood has had a long history of noise complaints. Even with a 10 dB to 20 dB reduction in sound level provided by a building or house (Table 2), communication indoors would be difficult during the peak of each jet aircraft event. Table 3 indicates that a 10 dB reduction of the outdoor 99 dBA maximum sound level would require people indoors to shout in order to communicate during those few seconds when the maximum sound level of the aircraft event occurs. (89 dBA level in Table 3)

A crucial factor that adds to the number of noise complaints is the high volume of jet departures (46 takeoffs per day). As people are exposed to increasing numbers of noisy aircraft events, their annoyance can increase significantly. The most annoying aircraft departures are most likely to be the six night departures. During the night, the ambient noise level of the neighborhood would drop below 50 dBA. These departing jet aircraft at night would be perceived as approximately 16 times as noisy as the neighborhood ambient level (Table 1).

The establishment of the new jet departure flight track will result in a reduction in the maximum sound level at the noise sensitive neighborhood by 5 dBA to 9 dBA for jet aircraft. This will be perceived as a reduction of noise at the noise sensitive neighborhood by almost one-half (Table 1) for some aircraft.

Departing jet aircraft on new flight track (B) will result in a maximum sound level at the noise sensitive neighborhood ranging from between 90 dBA and 85 dBA. Table 1 indicates that this will be judged as loud by most people. A 20 dB reduction in sound level provided by a building or house will drop sound levels indoors to approximately that of a television or vacuum cleaner (Table 1 - 70 dBA). Communication indoors will be possible during the peak of each aircraft event with a raised voice (Table 3 - 69 dBA interference level). The most annoying aircraft events will most likely remain those that occur at night when the ambient sound level of the neighborhood drops.

The establishment of the new jet departure flight track is expected to reduce to some degree the number of noise complaints. However, this neighborhood must still be considered as significantly impacted by aircraft noise. It is expected to continue to be a source of noise complaints. Future changes in airport layout and operation may provide additional noise relief.

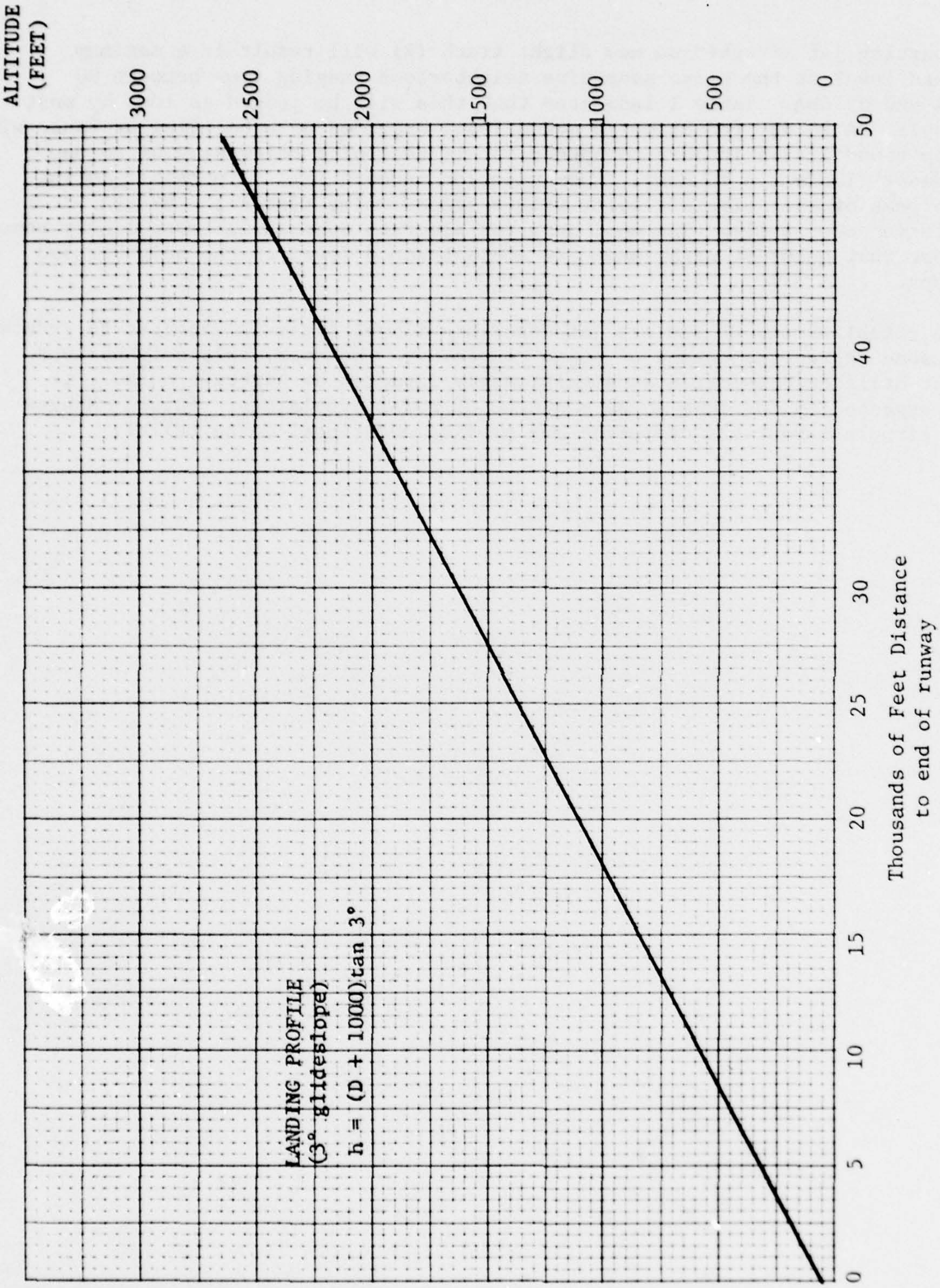
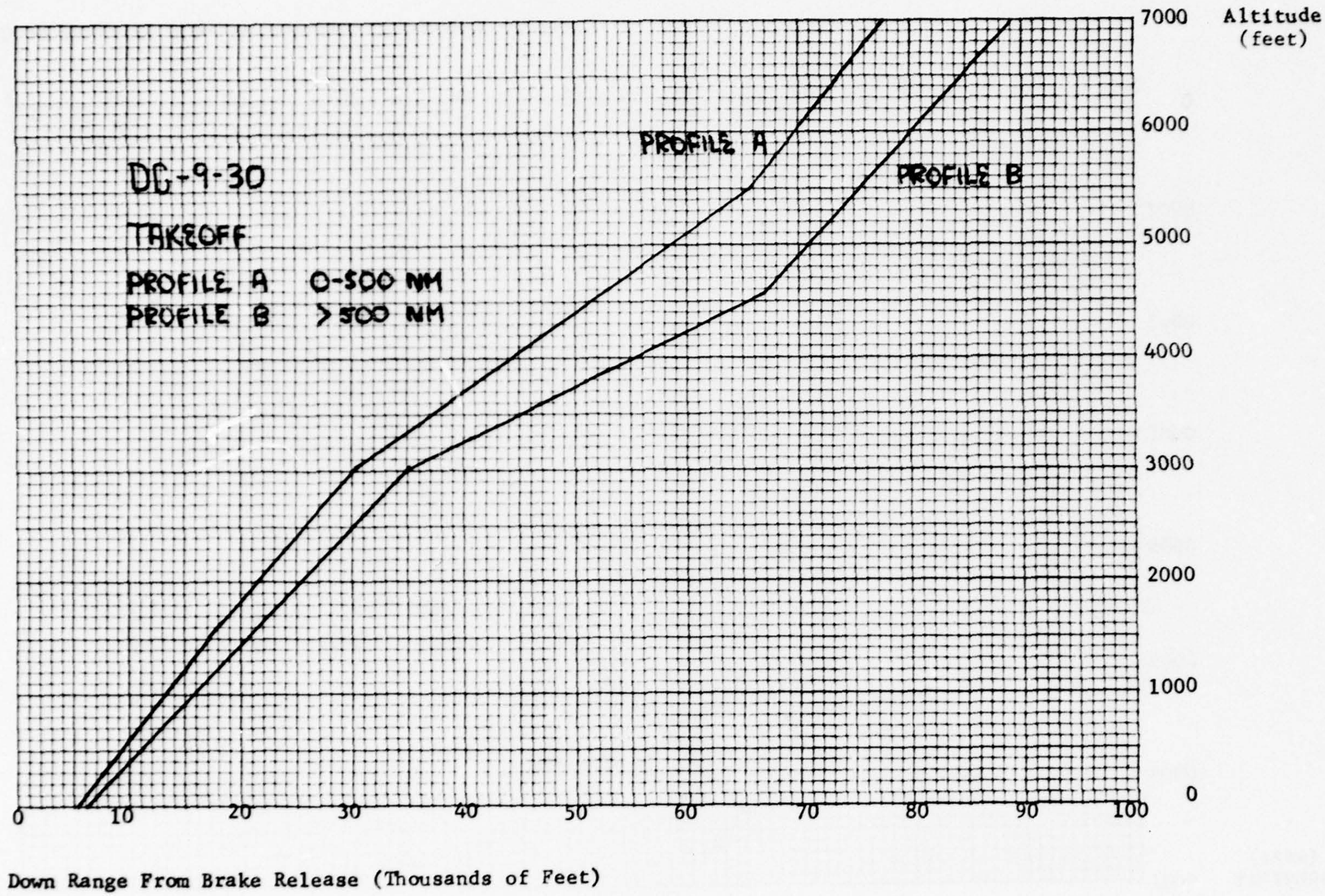

ALTITUDE (FEET)
3000
2500
2000
1500
1000
500
0
LANDING PROFILE
(3° glideslope)
h = (D + 1000) tan 3°
0
5
10
15
20
25
30
40
50
Thousands of Feet Distance to end of runway

FIGURE 11



DC-9-30
TAKEOFF
PROFILE A 0-500 NM
PROFILE B >500 NM
PROFILE A
PROFILE B
7000
6000
5000
4000
3000
2000
1000
0
Altitude (feet)
0
10
20
30
40
50
60
70
80
90
100
Down Range From Brake Release (Thousands of Feet)


FIGURE 12

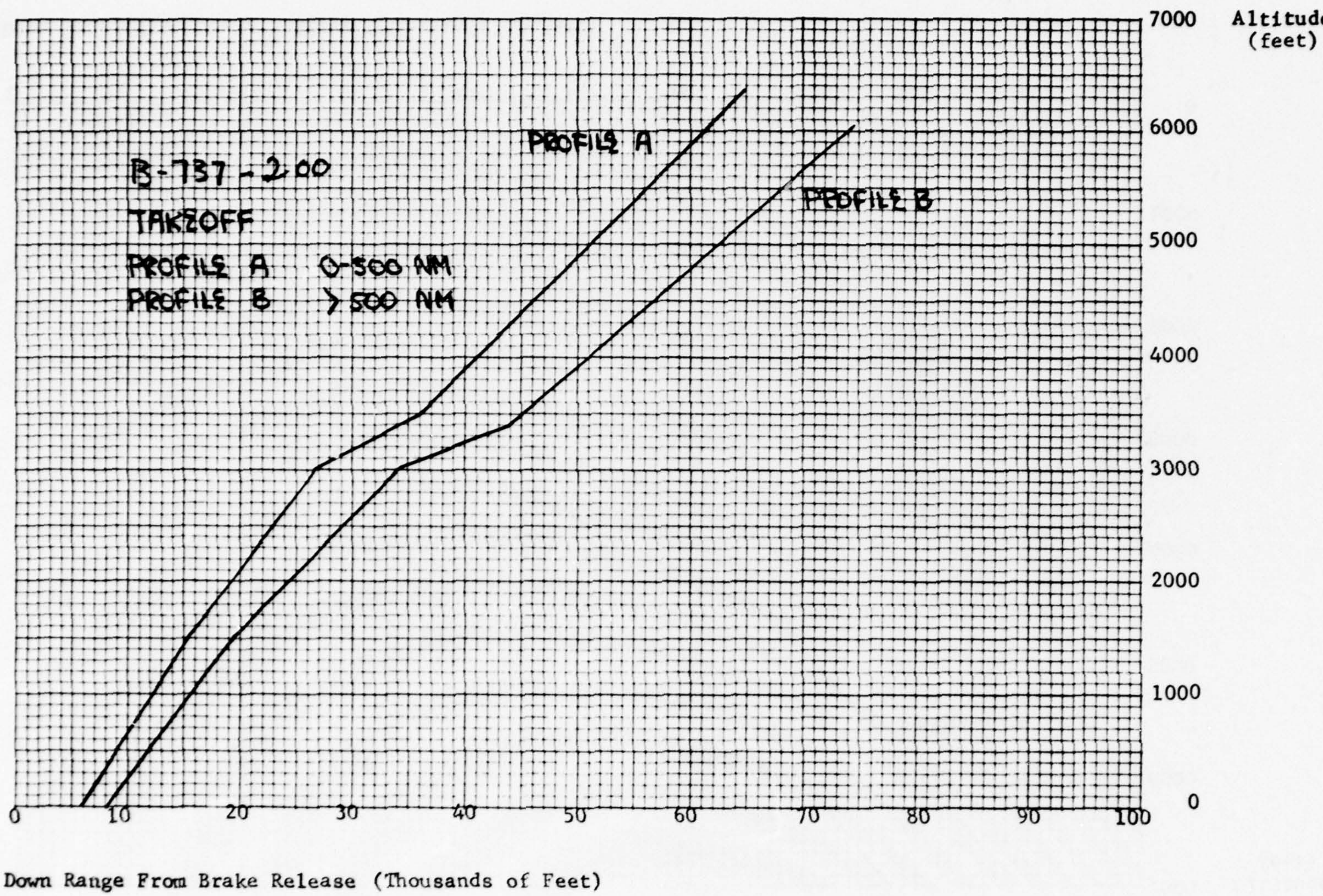

B-737-200
TAKEOFF
PROFILE A 0-500 NM
PROFILE B >500 NM
PROFILE A
PROFILE B
0
10
20
30
40
50
60
70
80
90
100
7000
6000
5000
4000
3000
2000
1000
0
Altitude (feet)
Down Range From Brake Release (Thousands of Feet)

FIGURE 13

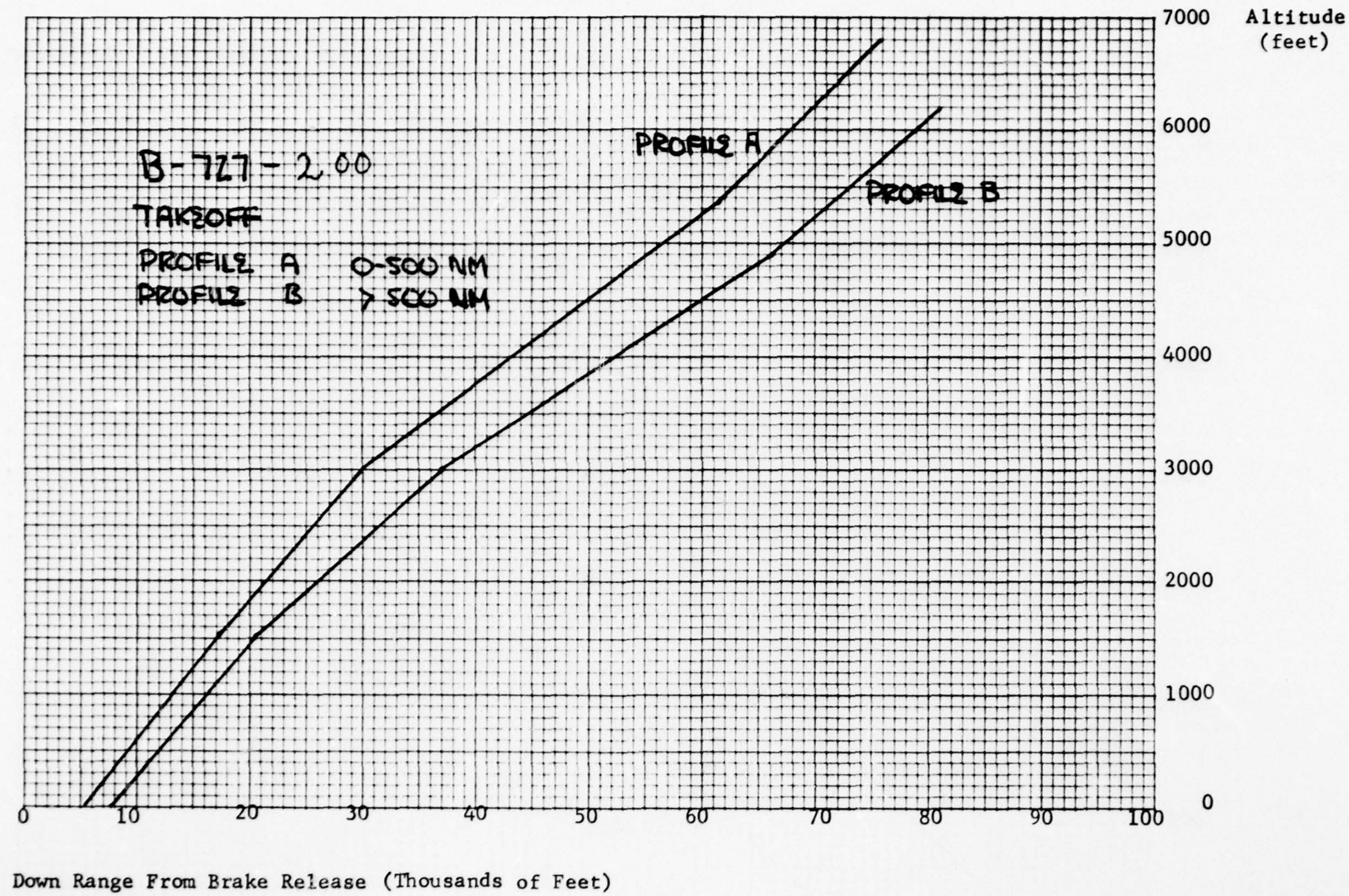

B-727 - 2.00
TAKEOFF
PROFILE A 0-500 NM
PROFILE B > 500 NM
PROFILE A
PROFILE B
7000
6000
5000
4000
3000
2000
1000
0
Altitude (feet)
0
10
20
30
40
50
60
70
80
90
100
Down Range From Brake Release (Thousands of Feet)

FIGURE 14

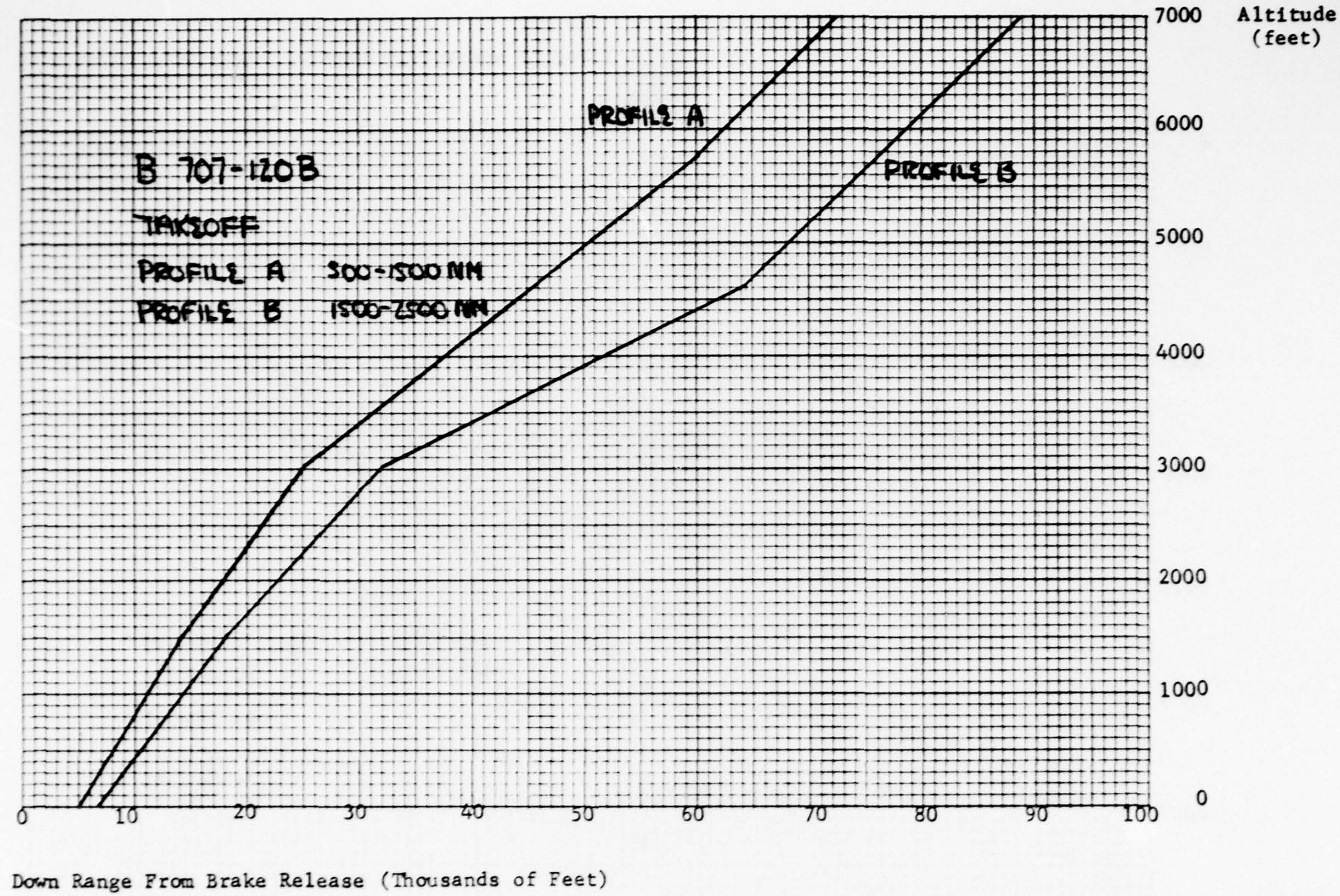
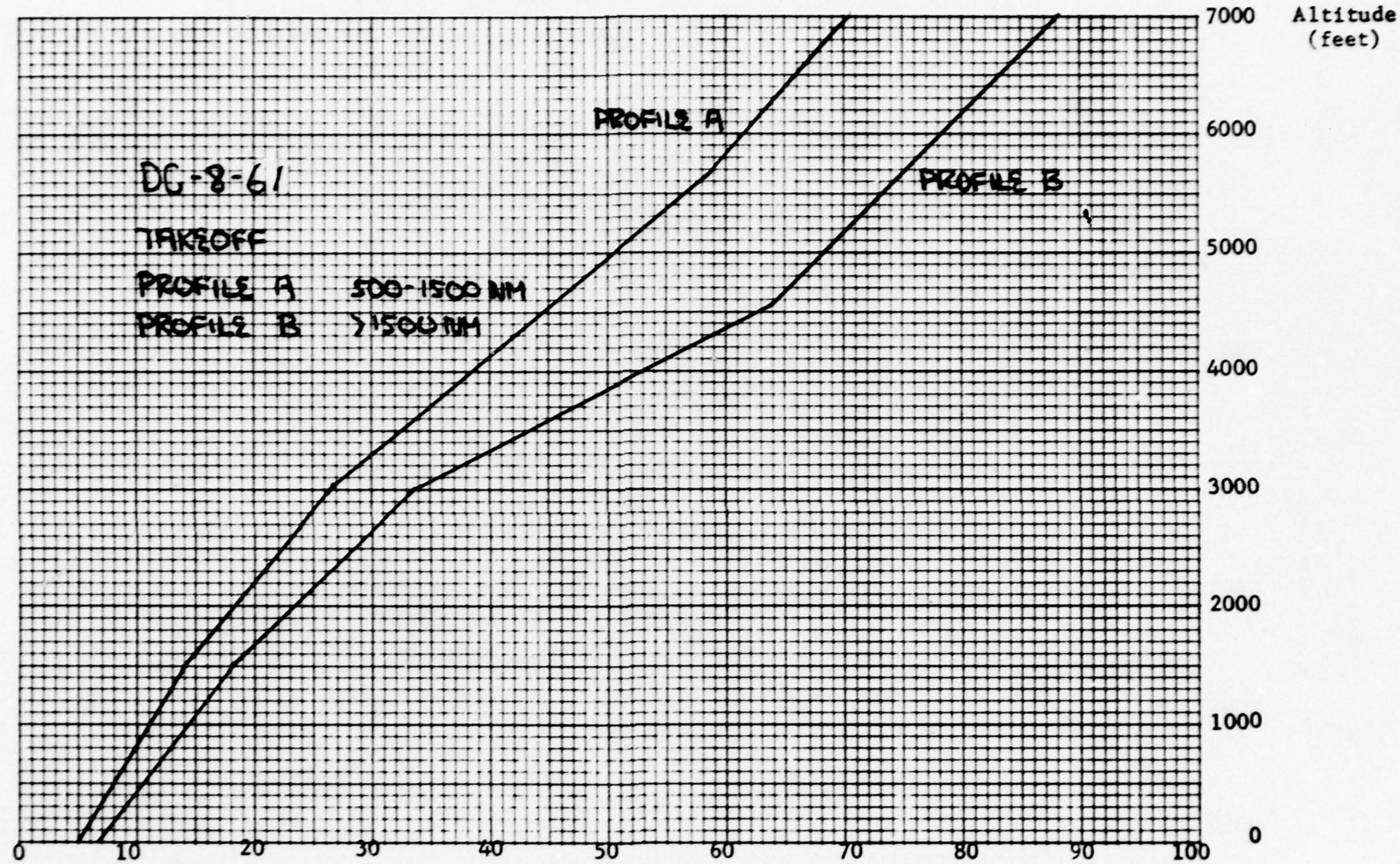
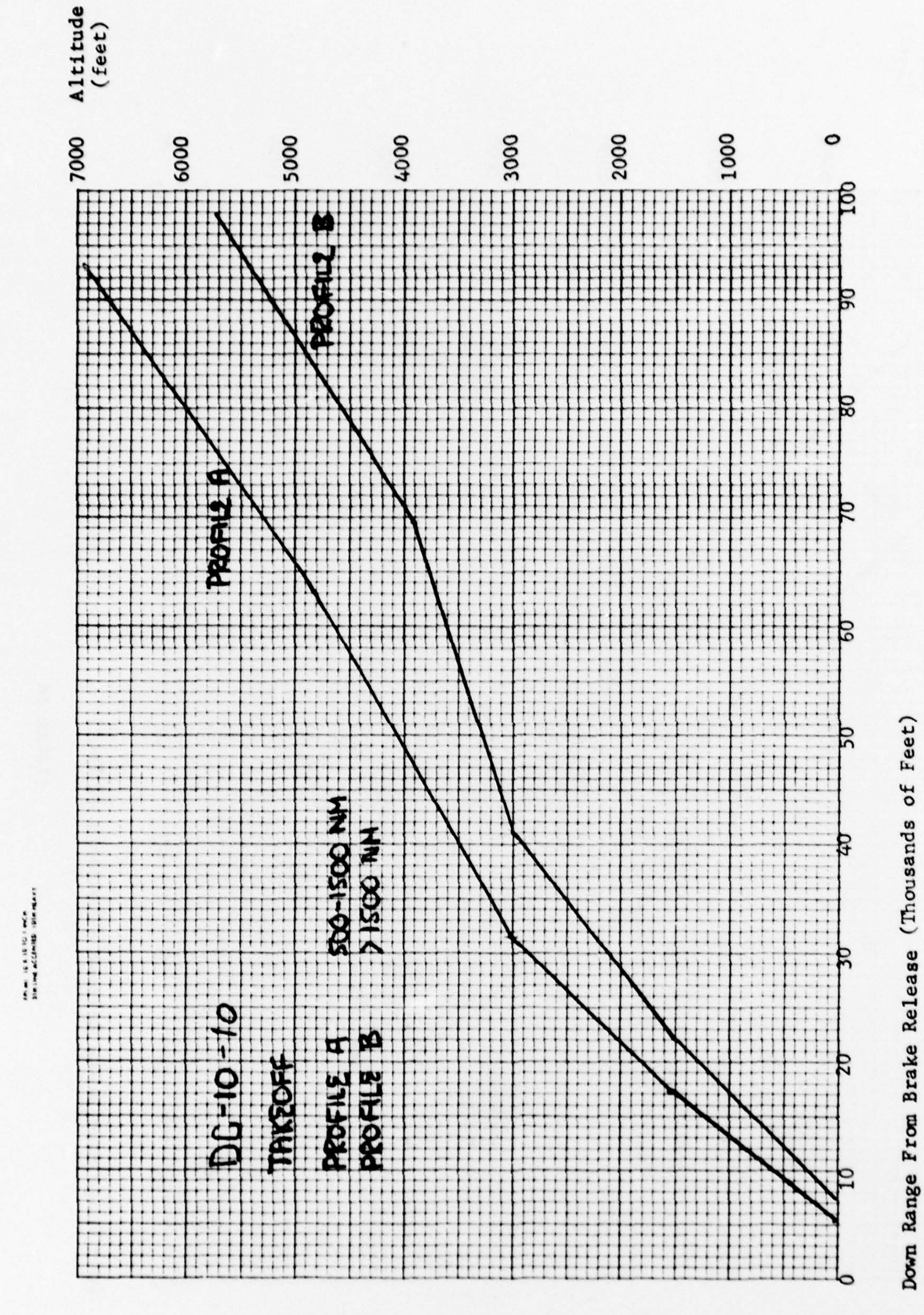

B 707-120B
TAKEOFF
PROFILE A 500-1500 NM
PROFILE B 1500-2500 NM
PROFILE A
PROFILE B
7000
6000
5000
4000
3000
2000
1000
0
Altitude
(feet)
0
10
20
30
40
50
60
70
80
90
100
Down Range From Brake Release (Thousands of Feet)

FIGURE 15




Down Range From Brake Release (Thousands of Feet)

FIGURE 16



DC-10-10
TAKEOFF
PROFILE A 500-1500 NM
PROFILE B >1500 NM
PROFILE A
PROFILE B
Altitude (feet)
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Down Range From Brake Release (Thousands of Feet)


FIGURE 17

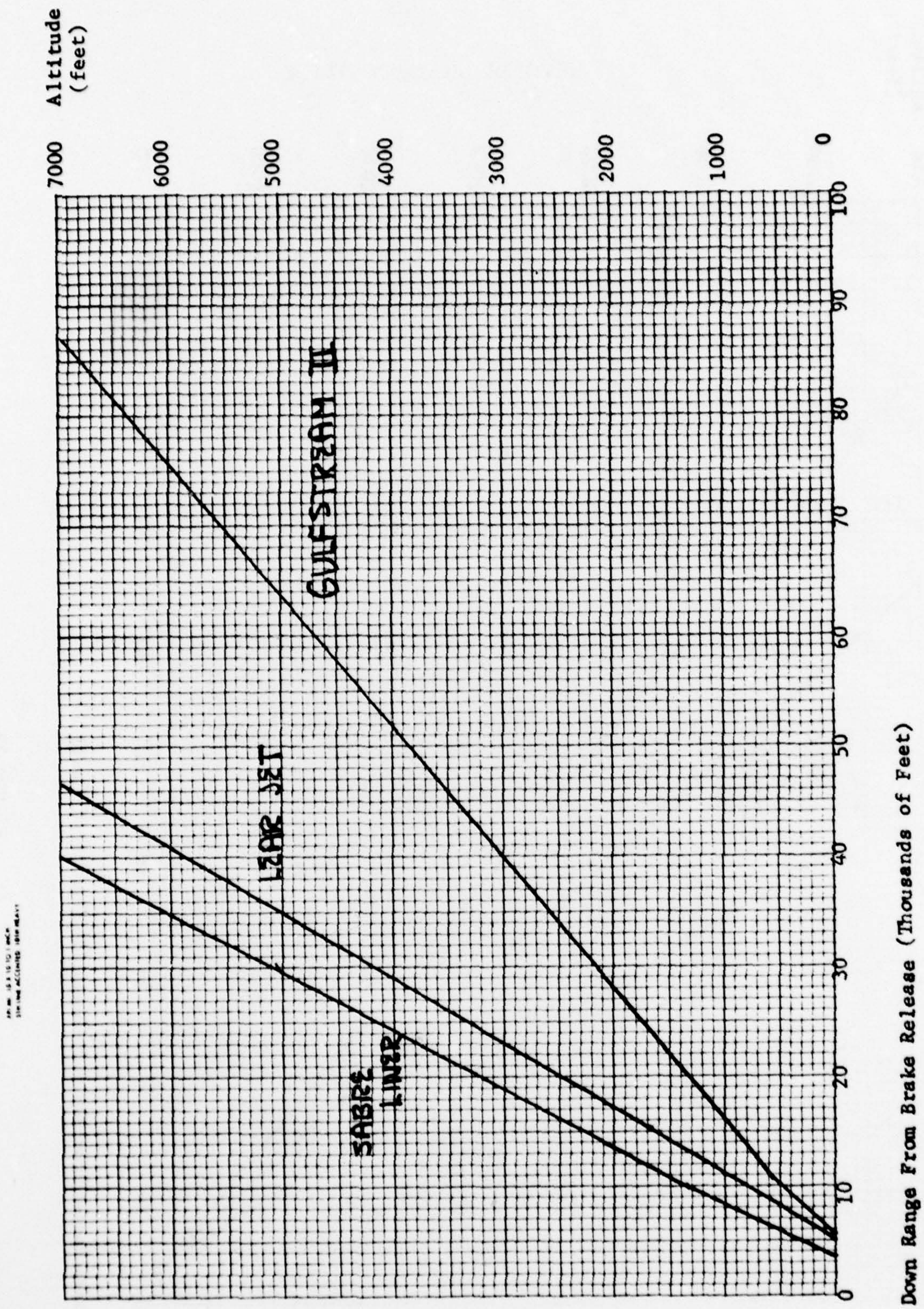

Altitude
(feet)
7000
6000
5000
4000
3000
2000
1000
0
10
20
30
40
50
60
70
80
90
100
Down Range From Brake Release (Thousands of Feet)
GULFSTREAM II
LEAR JET
SABRE LINER

FIGURE 18

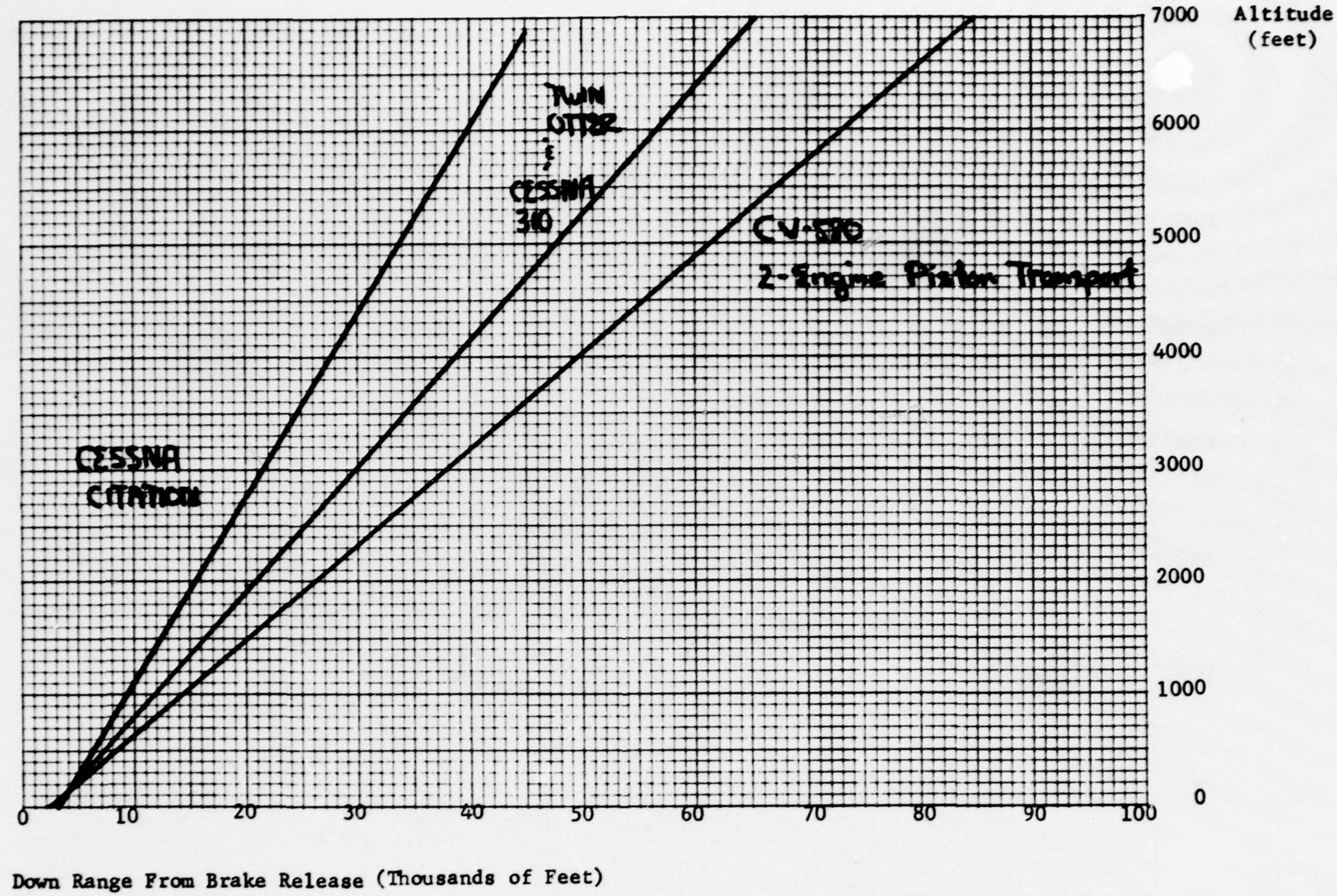

7000
6000
5000
4000
3000
2000
1000
0
Altitude
(feet)
0
10
20
30
40
50
60
70
80
90
100
TWIN OTTER
&
CESSNA 310
CV-580
2-Engine Piston Transport
CESSNA CITATION
Down Range From Brake Release (Thousands of Feet)

FIGURE 19

TABLE 4

NOISE TABLE

DC-9

Maximum A-Weighted Sound Levels

| Slant Distance (Feet) | Thrust Levels (Pounds Per Engine) 12000 | 10000 | 6000 |
|---|---|---|---|
| 300 | 111 dBA | 108 dBA | 105 dBA |
| 400 | 107 | 104 | 99 |
| 600 | 103 | 100 | 94 |
| 1000 | 98 | 94 | 87 |
| 2000 | 90 | 86 | 77 |
| 4000 | 81 | 76 | 66 |
| 6000 | 76 | 71 | 60 |
| 10,000 | 69 | 64 | 50 |
| 16,000 | 64 | 59 | 45 |
| 20,000 | 60 | 55 | 40 |

Takeoff Thrust

12,000 lb. until 1500 feet altitude
10,000 lb. above 1500 feet altitude

Landing Thrust

6000 lbs.

TABLE 5

NOISE TABLE

B-737

Maximum A-Weighted Sound Levels

Thrust Levels
(Pounds Per Engine)

| Slant Distance (Feet) | 12000 | 10000 | 4800 |
|---|---|---|---|
| 300 | 109 dBA | 106 dBA | 99 dBA |
| 400 | 105 | 104 | 93 |
| 600 | 101 | 100 | 88 |
| 1000 | 96 | 94 | 82 |
| 2000 | 89 | 86 | 72 |
| 4000 | 81 | 78 | 62 |
| 6000 | 76 | 73 | 57 |
| 10,000 | 68 | 66 | 50 |
| 16,000 | 64 | 59 | 41 |
| 20,000 | 60 | 55 | 36 |

Takeoff Thrust

12,000 lbs. until 1,500 feet altitude
10,000 lbs. above 1,500 feet altitude

Landing Thrust

4800 lbs.

TABLE 6

NOISE TABLE

B-727

**Maximum A-Weighted Sound Levels**

**Thrust Levels**
**(Pounds Per Engine)**

| Slant Distance (Feet) | 12000 | 10000 | 6000 |
|---|---|---|---|
| 300 | 110 dBA | 108 dBA | 104 dBA |
| 400 | 108 | 106 | 101 |
| 600 | 105 | 101 | 96 |
| 1000 | 100 | 96 | 89 |
| 2000 | 93 | 88 | 79 |
| 4000 | 85 | 80 | 69 |
| 6000 | 80 | 75 | 62 |
| 10,000 | 73 | 68 | 54 |
| 16,000 | 66 | 61 | 47 |
| 20,000 | 62 | 57 | 42 |

Takeoff Thrust

12,000 lbs. until 1500 feet altitude
10,000 lbs. above 1500 feet altitude

Landing Thrust

6000 lbs.

TABLE 7

NOISE TABLE

B-707

Maximum A-Weighted Sound Levels

Thrust Levels
(Pounds Per Engine)

| Slant Distance (Feet) | 14000 | 11990 | 3885 |
|---|---|---|---|
| 300 | 119 dBA | 117 dBA | 110 dBA |
| 400 | 113 | 112 | 105 |
| 600 | 110 | 108 | 100 |
| 1000 | 104 | 102 | 94 |
| 2000 | 95 | 92 | 84 |
| 4000 | 86 | 82 | 73 |
| 6000 | 80 | 76 | 65 |
| 10,000 | 73 | 68 | 55 |
| 16,000 | 65 | 59 | 48 |
| 20,000 | 61 | 55 | 44 |

Takeoff Thrust

14,000 lbs. until 1500 feet altitude
11,990 lbs. above 1500 feet altitude

Landing Thrust

3885 lbs.

TABLE 8

NOISE TABLE

DC-8

Maximum A-Weighted Sound Levels

Thrust Levels
(Pounds Per Engine)

| Slant Distance (Feet) | 15250 | 11990 | 3630 |
|---|---|---|---|
| 300 | 119 dBA | 117 dBA | 110 dBA |
| 400 | 113 | 112 | 105 |
| 600 | 110 | 108 | 100 |
| 1000 | 104 | 102 | 94 |
| 2000 | 95 | 92 | 84 |
| 4000 | 86 | 82 | 73 |
| 6000 | 80 | 76 | 65 |
| 10,000 | 73 | 68 | 55 |
| 16,000 | 65 | 59 | 48 |
| 20,000 | 61 | 55 | 44 |

Takeoff Thrust

15,250 lbs. until 1500 feet altitude
11,990 lbs. above 1500 feet altitude

Landing Thrust

3630 lbs.

TABLE 9

NOISE TABLE

DC-10

Maximum A-Weighted Sound Levels

Thrust Levels
(Pounds Per Engine)

| Slant Distance (Feet) | 30800 | 9200 |
|---|---|---|
| 300 | 107 dBA | 98 dBA |
| 400 | 101 | 91 |
| 600 | 97 | 86 |
| 1000 | 91 | 79 |
| 2000 | 82 | 68 |
| 4000 | 71 | 57 |
| 6000 | 65 | 50 |
| 10,000 | 58 | 42 |

Takeoff 30800 lbs.
Landing 9200 lbs.

TABLE 10

NOISE TABLE

CV-580 and 2-Engine Piston

Maximum A-Weighted Sound Levels

Thrust Levels
(Pounds Per Engine)

| Slant Distance (Feet) | Takeoff | Landing |
|---|---|---|
| 300 | 98 dBA | 88 dBA |
| 400 | 97 | 86 |
| 600 | 93 | 83 |
| 1000 | 89 | 79 |
| 2000 | 83 | 72 |
| 4000 | 76 | 65 |
| 6000 | 71 | 59 |
| 10,000 | 65 | 53 |
| 16,000 | 58 | 46 |
| 20,000 | 54 | 42 |

TABLE 11

NOISE TABLE

Sabre Liner

**Maximum A-Weighted Sound Levels**

**Thrust Levels**
**(Pounds Per Engine)**

| Slant Distance (Feet) | Takeoff 3450 | Landing 865 |
|---|---|---|
| 300 | 108 dBA | 96 dBA |
| 400 | 102 | 90 |
| 600 | 98 | 86 |
| 1000 | 92 | 80 |
| 2000 | 83 | 70 |
| 4000 | 74 | 58 |
| 6000 | 68 | 51 |
| 10,000 | 60 | 43 |
| 16,000 | 53 | 36 |
| 20,000 | 48 | -- |

**Learjet**

Maximum A-Weighted Sound Levels

Thrust Levels
(Pounds Per Engine)

| Slant Distance (Feet) | Takeoff 2500 | Landing 1050 |
|---|---|---|
| 300 | 112 dBA | 95 dBA |
| 400 | 110 | 93 |
| 600 | 106 | 89 |
| 1000 | 101 | 84 |
| 2000 | 92 | 77 |
| 4000 | 83 | 69 |
| 6000 | 77 | 61 |
| 10,000 | 69 | 54 |
| 16,000 | 61 | 46 |
| 20,000 | 55 | -- |

TABLE 12

NOISE TABLE

Gulfstream II

Maximum A-Weighted Sound Levels

Thrust Levels
(Pounds Per Engine)

| Slant Distance (Feet) | Takeoff 9300 | Landing 3200 |
|---|---|---|
| 300 | 110 dBA | 92 dBA |
| 400 | 108 | 90 |
| 600 | 105 | 86 |
| 1000 | 101 | 82 |
| 2000 | 95 | 75 |
| 4000 | 88 | 67 |
| 6000 | 83 | 62 |
| 10,000 | 77 | 55 |
| 16,000 | 71 | 47 |
| 20,000 | 66 | 42 |

TABLE 13

NOISE TABLE

Cessna 310

Maximum A-Weighted Sound Levels

| Slant Distance (Feet) | Takeoff | Landing |
|---|---|---|
| 300 | 88 dBA | 82 dBA |
| 400 | 84 | 77 |
| 600 | 81 | 74 |
| 1000 | 77 | 69 |
| 2000 | 70 | 63 |
| 4000 | 63 | 54 |
| 6000 | 59 | 49 |
| 10,000 | 53 | 42 |

TABLE 14

NOISE TABLE

Cessna Citation

Maximum A-Weighted Sound Levels

Thrust Levels

| Slant Distance (Feet) | Takeoff 1550 | Landing 510 |
|---|---|---|
| 300 | 90 dBA | 81 dBA |
| 400 | 88 | 78 |
| 600 | 84 | 74 |
| 1000 | 80 | 69 |
| 2000 | 73 | 63 |
| 4000 | 65 | 54 |
| 6000 | 59 | 48 |
| 10,000 | 52 | 40 |

Twin Otter

Maximum A-Weighted Sound Levels

| Slant Distance (Feet) | Takeoff | Landing |
|---|---|---|
| 300 | 88 dBA | 85 dBA |
| 400 | 83 | 80 |
| 600 | 80 | 76 |
| 1000 | 75 | 71 |
| 2000 | 68 | 62 |
| 4000 | 59 | 51 |
| 6000 | 55 | 43 |
| 10,000 | 47 | 33 |

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